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## THE NEW SPANISH SUBMARINE TORPEDO BOAT.

THE Spanish submarine boat Peral was constructed in the arsenal of Caraca, and was launched October 23, 1887. The boat is cylindrical in form and is 72 feet in length and 9½ feet in width amidships. It is provided with two screws, an electric motor and a torpedo tube.

The first experiments were made with it at the end of last February. The question was not to examine the qualities of the boat as a diver, but simply to verify its nautical capacity. It was therefore maneuvered at the surface. Unfortunately, one of the screws suddenly refused to revolve, and a landing had to be made to repair it.

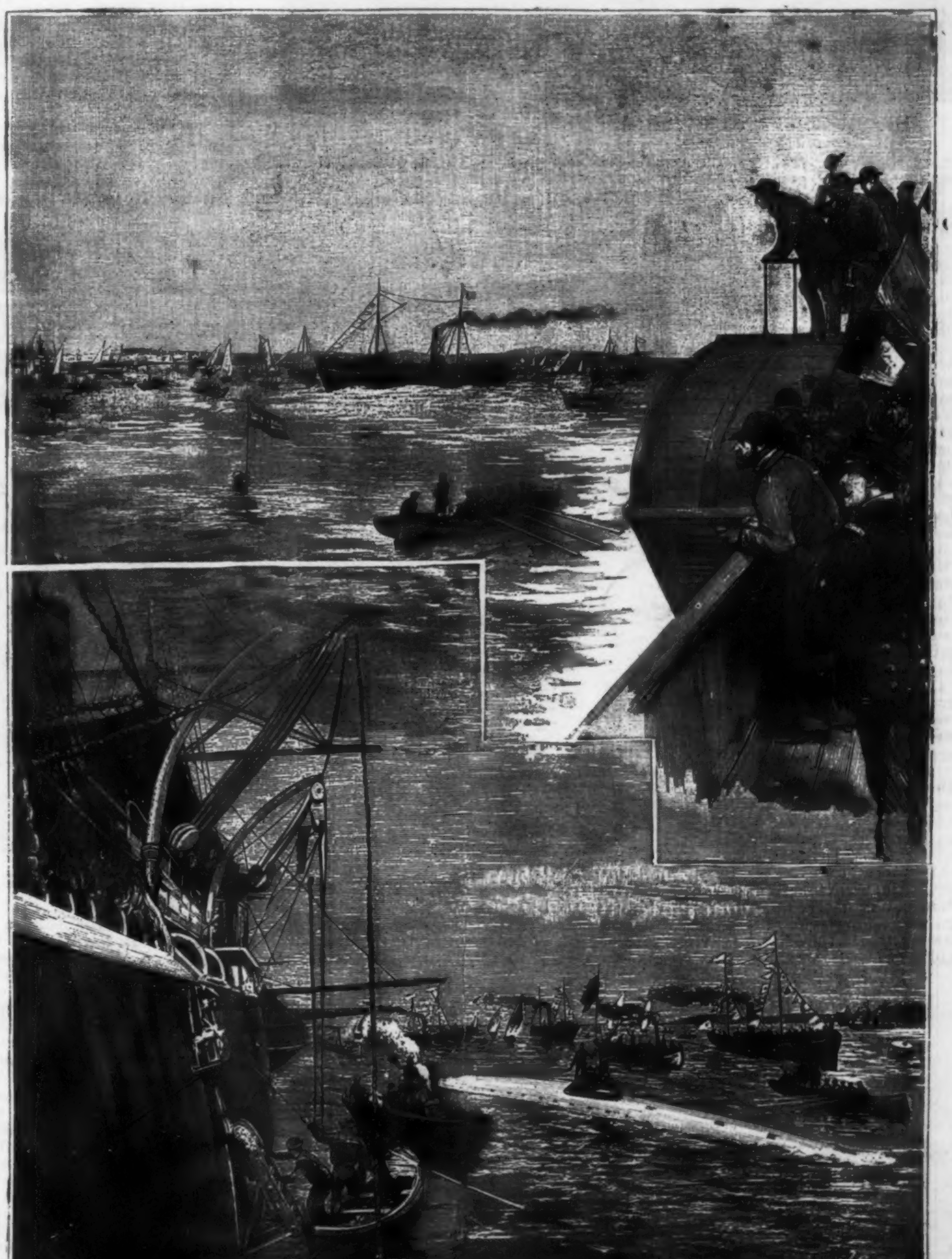
On the 20th of July the Peral started out for the second time, and no accident happened. The boat acted splendidly, and, as the *Cronica General* says, "obeyed its inventor as a slave obeys his master." But the Spaniards are enthusiasts, and long before the experiments they lauded the boat and its builder to the skies. The truth is that the eulogies bestowed by the Spaniards must be taken *cum grano salis*.

During the trials for speed, the boat was always meeting with some mishap—and it was even stranded on a sand bank. But a submarine boat is not designed to be maneuvered at the surface of the water; it is to navigate beneath. It must be confessed that in this respect the experiments were far from conclusive. The Peral certainly dived, but so few times that the Spaniards do wrong to boast of it. Our engravings are made from photographs taken during the experiment. The boat remained submerged for a quarter of an hour, but was immovable and attached to the wharf by a rope. From such an experiment, no conclusion can be drawn as to the boat's stability. Is it capable of remaining at a definite depth, and can it perform its evolutions freely at such depth? These questions cannot be answered, and it is necessary to await further experiments.

The above is from *La Science Illustrée*.

In addition to the foregoing we give from *La Ilustracion Espanola* two engravings illustrating the more recent trials of the Peral in the harbor of Cadiz. It was a beautiful day, the water calm, a gentle breeze. Several war ships were present, a large number of smaller craft, steamers crowded with spectators and decorated with bunting. The little submarine vessel moved about upon the surface of the water with a velocity of six miles per hour, turning short, stopping, and starting with the utmost facility. After a display of her qualities in these respects, her powers of sinking below the surface of the water and rising again were exhibited. Several times up and down she went, sinking until only half of her little tower, through which air was drawn, could be seen above the water. After going through a variety of evolutions, such as turning, stopping, backing, while in this position, that is, nearly submerged, the cap of the little tower was closed and the boat disappeared wholly beneath the water and remained under the surface for six minutes, only the flag upon the staff being visible. This feat of going entirely under aroused the greatest enthusiasm among the spectators.

After a total trial of three hours and a half, most of which time the boat was submerged, only leaving the little tower or air pipe half way above water, the performances were concluded, the boat rose, and Mr. Peral, the inventor, opened the manhole of the vessel and presented himself on the exterior with his hand on the flagstaff. This was the signal for an immense ovation. It is represented in one of our engravings. The air rang with the cheers of the populace, the bands gave forth their loudest music, flags waved from the shipping, and the steamers joined their screaming whistles to the general acclamations in honor of the worthy Peral and his companions, who had so successfully directed the little bark. It was, says our contemporary, a day of glory for the inventor and of prestige for Spain.



RECENT TRIALS OF THE SPANISH SUBMARINE TORPEDO BOAT PERAL AT CADIZ.

## RECENT PROGRESS IN SINKING DEEP FOUNDATIONS FOR ENGINEERING WORKS.*

By CHARLES ORMSBY BURGE, M. Inst. C.E.

AFTER a short introduction, the paper refers to the extension of railways, and the consequent necessity of bridging large rivers, as the chief cause of progress in deep foundations, and to the improvement in Portland and other cements as rendering chiefly such progress possible.

In earlier times timber piling was used exclusively for deep foundations, except in India, where a different method, to be adverted to presently, was pursued. The almost general substitution of iron for timber in engineering works led to the introduction of the screw pile, first used by Mitchell in 1834, since largely employed in bridging rivers and in marine piers, there being two forms, namely, hollow tubes of cast iron and solid forgings of wrought iron. These piles are, however, unsuitable for very deep foundations where the overlying material is soft or liable to scour, as it is impossible to brace the piles below ground, and the whole structure may therefore become unsteady. Instances of large bridges of this type with which the author has been connected are given, in which cylindrical piers had to be subsequently substituted for piles. Many marine piers have been constructed successfully on screw piles, as they are not subject to heavy and fast traffic. One at Hueiva, in the south of Spain, is specially mentioned as embodying a novel principle of obtaining increased bearing surface, the area of the screw blades being considered insufficient. Large platforms were sunk around each group of piles, as far as they would go, when temporarily loaded with weights largely exceeding the permanent maximum load on the group. They were then strongly connected with the piling, and the temporary loading removed; the pier, therefore, chiefly rests on these platforms, the extension of the piles below serving principally to steady the whole.

Cylindrical foundations are next referred to, commencing with the primitive native Indian brick well, only large enough for a man to work inside of, built on wooden curbs, often cemented by mud only, and held together by straw ropes in sinking. Native divers descend in them to a depth of 17 ft. below water, excavating and bringing up basketfuls of sand, and numbers of these wells, sunk close together and filled with concrete, have been used for railway bridge foundations; the concrete in those sunk by the author being made in those days of one part lime, two of brickdust, and four of broken stone. Such wells were sunk in India, complete including everything, for about 16s. per lineal foot. Larger brick wells, and fewer in number, are more in use latterly; they are 18 ft. and upward in diameter, with iron curbs, and have been successfully sunk to over 100 ft. below beds of rivers. A description is given in this paper of a curious operation witnessed by the author at Cawnpore, when the remains of the submerged wells of a bridge previously carried away by flood were blown away under the sand by gun cotton, to make room for the foundations of the present Ganges bridge at that place.

Iron cylinders sunk and filled with concrete are then alluded to, as most generally in use out of India, and having the advantage over brick where deep water has to be dealt with, Mr. Barlow combining both systems in the new Tay bridge, the foundations of which, and the mode of operations, being described in detail. The stability of cylindrical piers against overturning by flood or drift wood is adverted to, and instances given of the two cylinders forming a pier being connected together by solid plating in South African bridges to attain this object. Where the sinking is not guided by piles, tapering out at bottom of the cylinders is strongly deprecated, experience amply showing that this renders true vertical sinking very difficult. Where water-bearing strata have to be passed through with obstructions which cannot be removed except by actual manual

* From "Proceedings of Australasian Association for the Advancement of Science," Sydney, 1888, p. 564.

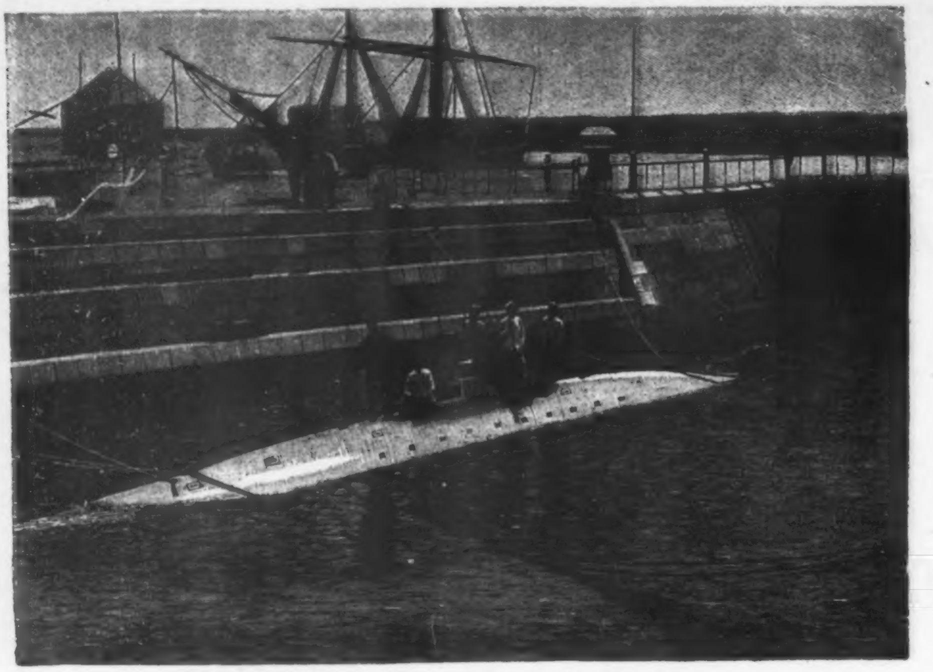


FIG. 1.—THE PERAL BEFORE SUBMERSION.

labor, and where the largeness of the area gives room to work in, the pneumatic process has been generally adopted.

While applicable to and often used in cylinder work, the method is indispensable in inverted caissons. The caisson is like an inverted box with the open side downward, and the masonry is begun on the top, which is made specially strong, and is proceeded with as the caisson sinks into the ground, excavated by the men inside of it. Holes or shafts are left in the masonry for the passage of men and material to and from the caisson, and for the supply of the compressed air which is introduced to force out the water and enable the men to work. Each shaft is provided with an airlock, a contrivance for preventing escape of compressed air, which is fully described. When the desired depth is reached, the caisson is filled with concrete and left as part of the permanent work. The pneumatic system has its limit at about 100 ft. below water level, as men cannot work properly under greater pressure than is necessary to sustain a column of water of that height.

In the great Brooklyn bridge the caisson is of timber strongly roofed, and in the deeper pier, which is founded 78 ft. below water, it is lined with iron. It was sought in this case to avoid the expense and delay of passing the excavated material through the airlocks, by constructing separate dredging tubes open to the air, which passed through the caisson and below the level of its cutting edge and of the compressed level of water. The workmen excavated around the foot of these shafts in the caisson, so that the material sunk through the water and under the edge of the dredging tube, inside of which ordinary dredging grabs, working in the usual method, removed it; but it was not a success, as, notwithstanding the care that was taken to keep the foot of the tubes below water, there was a great loss of compressed air.

These caissons are among the largest ever constructed, being 102 ft. by 168 ft. each, with 9 ft. 6 in. depth of chamber, the Brooklyn pier being founded on trap bowlders embedded in clay and sand, 45 ft. below high water, and the New York one is sunk through quicksands to rock at a depth of 78 ft. below the same level. Standing on this enormous structure, which rises 135 ft. above the crowded river, with a span of nearly 1,600 ft., and turning from the magnificent view around, one can hardly realize how the lower parts of the solid masonry of the huge towers could have been actually, so to say, floated and sunk with such steadiness and accuracy as to be effectual for their purpose.

In the Forth bridge the caissons, which are of iron, are circular, 70 feet in diameter at the base; four of these forming one of the great piers. There is a 7 foot working chamber at bottom, but the walls are carried up above the roof, and pockets inside the circumference of these upper walls are constructed so as to enable any point to be loaded with concrete, and the sinking to be regulated. Notwithstanding this, one of the caissons tilted over in sinking, and much trouble, delay, and expense were incurred before it was righted. The weight on these foundations, including the tilting action of a wind pressure of 56 pounds per square foot, is about six tons per square foot. The foundations of the four legs or pedestals of the great Eiffel tower in Paris are similar in type, four caissons being used for each foot. The pressure, including the enormous leverage produced by the effect of wind on a structure nearly 1,000 feet high, is estimated at under four tons per square foot.

The center pier of the Harlem River bridge, New York, supporting the thrust of a 510 foot arch on each side of it, stands on a timber caisson 104 feet by 54 feet by 18 feet deep, divided into three compartments by vertical partitions. These partitions, besides strengthening the caisson, afforded shelter to the men during blasting, as the bottom was rock of greatly inclined surface. One of the most difficult feats in this kind of work was the sinking of a wooden caisson foundation for a lighthouse in Delaware Bay, an exposed position open to the full fury of the Atlantic. It was towed out with part of the cast iron shaft upon it, and then further loaded and sunk. The compressed air in this case was also made use of to force out the sand up through vertical pipes. Beyond the pneumatic limit, about 100 feet under water level, all excavation must be done by dredgers, and special care is required in the design, that no contingency shall arise at the bottom which has to be dealt with by manual labor, diving operations being impossible. At these depths also the skin friction, unimportant in a cylinder of moderate depth, becomes so great that special arrangements for overcoming it must be provided.

There are four well-known railway bridges, two now in course of construction, and two completed, in which these difficulties had to be met—the Benares bridge over the Ganges, the Poughkeespie over the Hudson River, the Hawkesbury bridge in New South Wales, and the Jubilee bridge over the Hooghly in Bengal. In the Benares bridge the principal piers are sunk to a depth of 140 feet below water level, and are formed of oval brick wells 65 feet by 28 feet, and as they had to be begun in water, the bottom lengths are cased in iron. Each is divided into three compartments, in which the dredging is carried on. In the Poughkeespie and Hawkesbury foundations somewhat identical principles are adopted, namely, caissons divided into dredging and loading compartments. In the American work the caisson is of timber, 160 feet by 60 feet by 125 feet deep, divided vertically into forty cells, the sinking, which is to be about 130 feet below water, being effected by filling in some of them and excavating in others. In the Australian bridge the caisson is oval and is of steel and iron, 48 feet by 20 feet, splaying out at bottom 2 feet more all round, and it has three dredging wells in line at the center, parallel with its length, and splaying out to meet the outer skin and each other at the bottom in a cutting edge. Between the wells and the outer skin, which are strongly stayed together, the space is filled with concrete as the structure sinks. The greatest depth, which is also believed to be the greatest ever reached in a bridge foundation, is 161 feet below water level. In the Hooghly bridge the caisson is somewhat similar in shape to the Hawkesbury one, but has a completely vertical outer skin, and the three dredging spaces extend right across the structure, occupying the semicircular ends and the central portion. Weight is obtained by concreting the two 15 feet intermediate spaces, and by a brick lining around the semicircular ends. In all these cases the wells are, of course, filled up with concrete when the bottom is reached.

This review as to what has been done is now brought down to the latest date, and a few remarks, founded on practical experience of several years' standing, of the majority of the systems mentioned, may be made. No general principle can be laid down as to the preference of any one system over another. As in medicine, so in engineering, and especially as regards foundations, not only does every disease require its own physic, but even the same disease in different

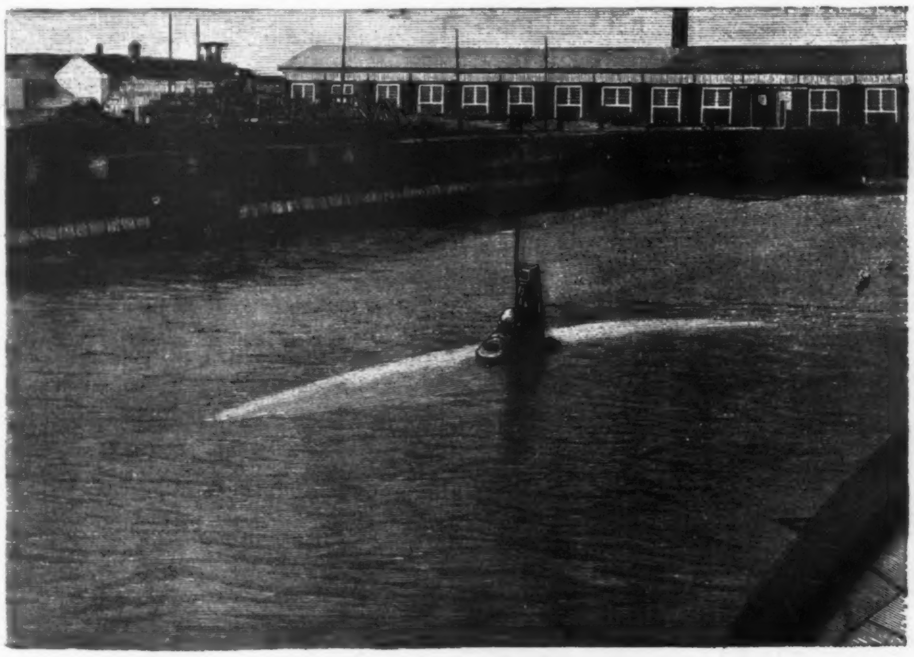


FIG. 2.—THE PERAL—PARTIAL SUBMERSION.

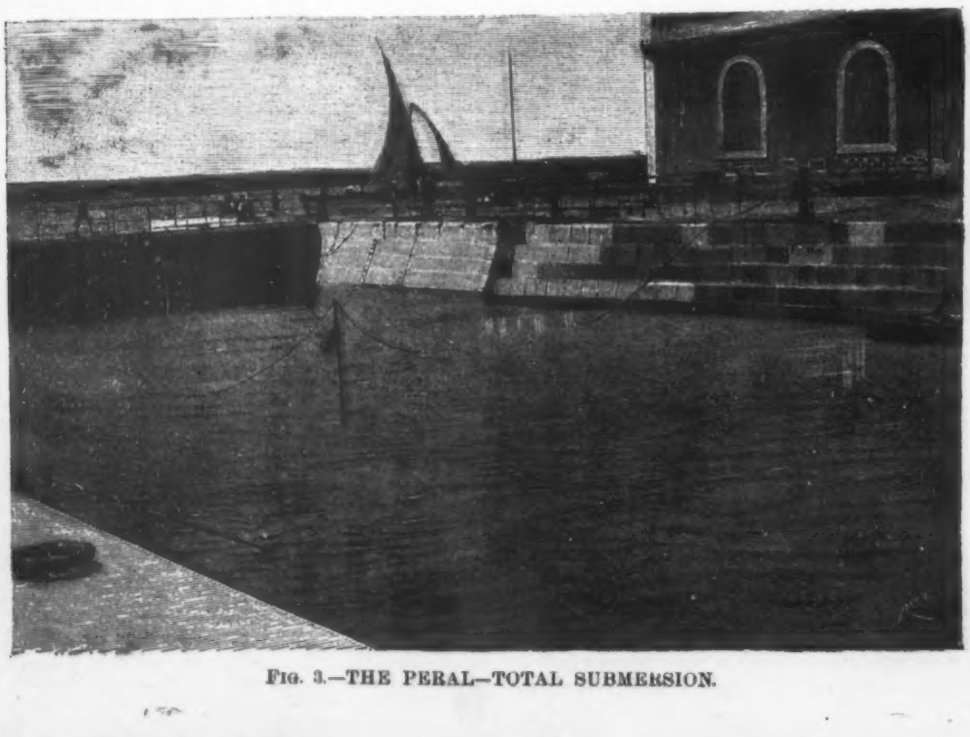
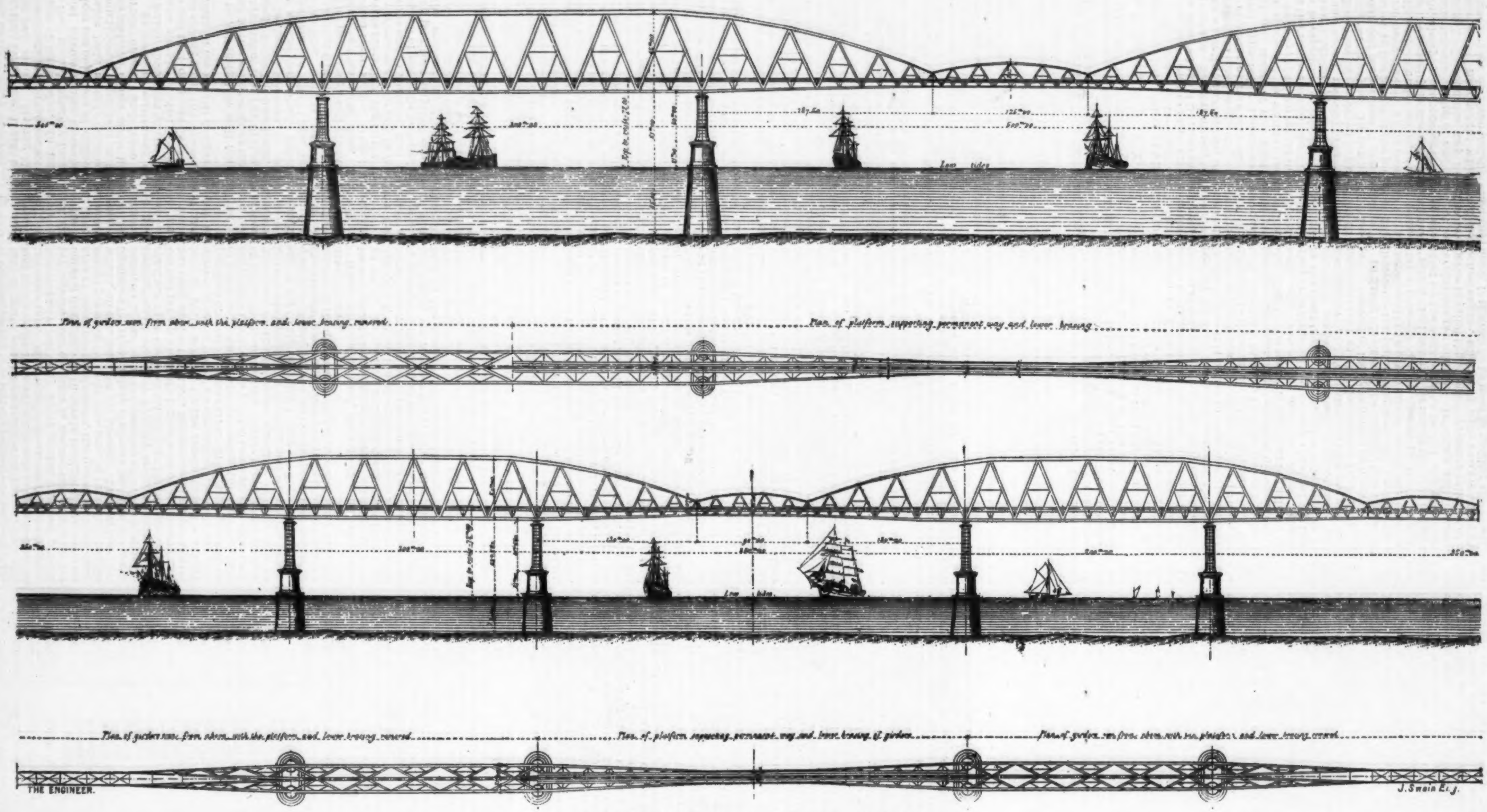


FIG. 3.—THE PERAL—TOTAL SUBMERSION.




THE PROPOSED CHANNEL BRIDGE.

DESIGNED BY MESSRS. SCHNEIDER & CO. AND M. H. HERSENT; SIR JOHN FOWLER AND MR. BENJAMIN BAKER, MM. INST. C.E., CONSULTING ENGINEERS.

[For description see page 11564.]

individuals demands separate intelligent treatment. Any remarks, therefore, that are made in this paper must be considered as thoroughly subordinate to this general principle, that every case must be met and dealt with on its own merits. Having this in view, it must be first remarked that great caution should be exercised in the use of screw piles. In railway structures of any size they should certainly be avoided, except under special circumstances favorable to their use. Not only does the objection of difficulty of bracing below scourable beds, already alluded to, arise, but the whole foundation is dependent on the comparatively perishable material of the screw blade, which in time may corrode unseen, and leave insufficient bearing surface. Subsequent settlement of one pile may distort and strain important parts of the upper structure. Failures already alluded to within the author's experience and that of others have led to these opinions—failures arising from the system itself and not from any defects in the special designs adopted in these cases.

With respect to cylindrical or well foundations, it has always seemed to the writer strange that, with few exceptions, notably that of the Tay bridge, the system of brick wells should be confined to India. There are plenty of rivers bridged elsewhere, in which sandy beds, dry nearly all the year round, point unmistakably to this expedient—in the Cape, for instance, where, notwithstanding, iron is preferred. Brick cylinders have the great advantage of supplying their own weight, and of providing a more permanent coating to the concrete core than metal does. Nor will it be found, even when local skilled labor is expensive, that the former costs more than the latter.

The pneumatic processes are largely in favor on the continent of Europe and in America, and illustrate a successful application of scientific knowledge to practical work. It is a pity that physical conditions limit the extent of the application. The effect of highly compressed air on the human system is that the blood is driven in from the exterior and soft parts of the body to the central organs, especially to the brain and spinal cord, causing violent neuralgic pains, and sometimes paralysis.

There is hardly sufficient experience yet of the system of a double casing with the weighting material between, employed at the Poughkeepsie, the Hooghly, and the Hawkesbury, to enable the law to be laid down with regard to them, but the experience so far gained by the author at the latter bridge appears to show that where a great depth has to be reached, there must be ample latitude given in the size of the caisson in plan, so as to allow for any divergence that may occur in sinking. Such divergence, trifling in a shallow foundation, may become serious in a deep one, and the enormous weight of the structure renders control very difficult. Such control may, in the opinion of the author, be given to some extent, in the first place as regards horizontal divergence, by the shape of the lower portion, which should be vertical on the outside. Any outward splay given to this part may intensify a lateral movement, however caused, in the direction of the splay on one side by a wedge-like action, while the similar splay on the opposite side has no counteracting influence.

In the second place, to counteract any tilting action, the dredging holes should be sufficient in number, and so placed that by dredging in any one a "straightening-up" effect can be produced; that is to say, there should be four at least, so as to control tilting action toward any of the four cardinal points. It must be remembered that in dredging these deep holes, the slightest tilt throws the dredging grab over to that side of the well, at the bottom, which, in order to recover verticality, ought to be avoided, as it tends to undermine that cutting edge which is already too low. It is different from the case of a foundation of a single large shallow well or cylinder, which can be dredged at any desired point, and that side sunk accordingly.

In the multiple tube system, as it may be called, on the contrary, each well must act for itself in regulating the descent on its own side, and its position should be so fixed in the design as to lead to that result. As these caissons must necessarily be deep in proportion to their area, there is no chance by weighting them unevenly to restore their balance, except when the sinking is just begun.

[Continued from SUPPLEMENT, No. 733, pag 11709.]

## SIBLEY COLLEGE LECTURES.—1889-90.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

### I.—THE ADAPTATION OF THE STEAM MACHINERY IN MARINE CONSTRUCTION.

By CHAS. E. EMERY, Ph.D., N. Y. City.

A FORM resembling our land boilers, in which the furnace is located below the circular shell and return tubes inside it, has been used to some extent in this country, and it is believed could be more generally employed with advantage. Several attempts have also been made to use water tubular boilers, in which all the water is contained in small sections, thereby reducing the weight of water carried and increasing the safety, the general type being known as "sectional boilers." No sectional boiler of this kind has as yet been sufficiently successful to warrant its adoption. Many engineers do not yet feel warranted in constructing boilers with the furnace under the shell, and the locomotive type is expensive in construction and repairs, so that the cylindrical type first named is more generally used; and we will proceed to examine in detail the steps which may be employed in fixing the dimensions of a boiler of this type. In the previous lecture, on the "governing proportions of steam boilers," attention was called to the fact that the power of the boiler being principally limited by its power to burn coal, the proportion which under ordinary circumstances most affects the capacity is the cross area of the tubes for draught, always presupposing that the grate is of ample size and the smoke pipe of ample height to produce the draught. Calculations may be made ascertaining the intensity of the draught which will be secured with a smoke pipe of given height when the joint resistances of the tubes, connections, and grate are considered, but ordinarily it is quite sufficient to know the quantity of coal which can be burned per square foot of grate with the draught available in steamers of the same class. In the naval vessels used during the war, with smoke pipes sixty feet high above the grates, it was considered that sixteen pounds of coal per square foot of grate could be burned with natural draught, and in the merchant service it is safe to estimate about the same rate. With smaller steamers and smoke pipes barely forty feet high above grates, fourteen pounds per square foot of grate is nearer the maximum for natural draught. If the grate be eight times the cross area of the tubes for draught, the quantity of coal consumed per square foot of cross area of tubes for draught would, on this basis, be 112 pounds. The average performance for regular duty is always less than the maximum, so it has been the practice of the writer, in designing small steamers without artificial draught, to consider that there would be only 100 pounds of coal burned per square foot of cross area of tubes; and this has been used rather than the consumption per square foot of grate surface, for the reason that it is a more correct index of power on account of the different proportions of grate to cross area. If a large proportion of grate be provided, the resistances through the grate are reduced, but with a greater proportional cross area of tubes the head to draw the air through the grate is increased, so that a larger quantity of coal can be burned per square foot of grate, and within the limits, say of 7½ to 8½ of grate to one of draught area, the quantity of coal burned will be proportioned nearly to the draught area, but when the grate is proportionally smaller it should be considered in connection with the draught area.

When blowers are used, the rate of combustion can be very greatly increased, and special calculations must be made. In modern compound engines with forced draught, 8, 10, and in exceptional cases as many as 20 horse power have been procured for each square foot of grate, but the highest performance cannot be calculated upon for regular work. For illustration, going back to the results with natural draught, if there be but 100 pounds of coal consumed per square foot of draught area, or, for average proportions, 12½ pounds per square foot of grate, and there be 600 I. H. P. to provide for; if the steam is to be used in engines requiring 20 lb. of water horse power per hour in actual practice, and the same is to be generated in boilers which in ordinary practice evaporate but 8½ pounds under actual conditions, it will be seen that there must be consumed 2·353 pounds of coal per I. H. P. per hour, or for 600 horse power 1,412 pounds per hour, on which basis there would be required 113 square feet of grate, or 56½ square feet in each of two boilers. If each boiler be provided with three circular furnaces, 3 feet in diameter, or for each boiler 9 feet aggregate width, the length of grates should be a trifle over 6 feet. As has been explained, it is more important, however, to get sufficient draught area to burn 1,412 pounds of coal per hour, which, at the rate of 100 pounds per square foot of draught area, would require 7·06 square feet of draught area in each boiler. There will be appended to this lecture, when published, a table showing the cross areas of boiler tubes for draught and the heating surfaces per foot of length of different sizes of standard boiler tubes, from which, selecting the cross area of the size of tube to be used, the number of tubes required will be easily ascertained. In selecting the size of tubes, practical considerations are of greatest importance. On rivers, in the waters of which there may be considerable mud and silt, it is customary, as previously stated, to use quite large tubes, even those of 6 inches and 8 inches in diameter, which may be called flues. About the harbors and on the coasts, it has been usual to employ tubes of 4 inches diameter, but at sea and to some extent in harbor work it has become customary to reduce the size of the tubes, and thereby decrease the length of the boilers. This has been the case particularly as higher pressures were employed, so that now 3 inch tubes are very common in marine work, and there are numbers of instances where tubes as small as 2½ inches in diameter have been used. The same cross area for draught cannot as readily be obtained in a boiler shell of given diameter with small tubes as with large, but the difference is not great. While the small tubes decrease the length and weight of a boiler, they also diminish the disengaging surfaces for steam, and the steam space, so that the diameters for a given power are necessarily somewhat in excess of those in which large tubes are employed. If then we assume in the case in hand that in each of the two boilers we are to use 3 inch tubes, we find by table that the cross area of a 3 inch tube is 0·042 square foot, so that there will be required 168 tubes of that diameter for each boiler. It then becomes necessary to make a drawing in cross section of the boiler to ascertain what sized shell will be required to contain this number of tubes. The three furnaces are first to be arranged in the bottom of the shell, separated from each other and from the shell 4 to 5 inches, the smaller dimension being sufficient if care be taken in the construction of the boiler. The tubes can then be arranged in horizontal and vertical rows above. The exact arrangement varies with different builders. In boilers of 8 or 9 feet diameter, they can be distributed equally between the water spaces at the sides, but in larger boilers it is better to leave a central water space three or four times the ordinary width between tubes, in addition to those at the side, for circulation. The writer's practice is to make the side spaces 9 inches in the clear, so that a small man can work his way down outside the tubes to the spandrel spaces at the sides of the furnaces and clean off any deposits. Access between and above the furnaces is generally obtained by manholes in the front head. The furnace tubes are at present generally made corrugated, in accordance with the Montgomery and Fox patents, which are now regularly manufactured at the Continental Iron Works, Greenpoint, instead of being imported as formerly.

In fixing the sizes of the engines, it is well at first to determine the piston displacement per minute which corresponds to a given power under the conditions of steam pressure and expansion in the cylinder. [By "piston displacement" is meant the area in feet multiplied by the double stroke in feet and the number of revolutions per minute.] In doing this, it should be borne in mind that the low pressure cylinder of a compound engine, whether it have two cylinders, three or more, is the one to be used in making the calculations for displacement, entirely independent of the sizes of the other cylinders, as the slightest consideration of the subject will show that since the effective pressure in the larger cylinder is practically the back pressure in

BOILER TUBES.

| Outside Diameter. | Internal Cross Area. | External Surface per Foot of Length. |
|---|---|---|
| Inches. | Square feet. | Square feet. |
| 1 | 0 003993 | 0·2618 |
| 1¼ | 0·006722 | 0·3272 |
| 1½ | 0·009646 | 0 3927 |
| 1¾ | 0·01327 | 0 4581 |
| 2 | 0·01787 | 0·5236 |
| 2¼ | 0·02315 | 0·5891 |
| 2½ | 0·02835 | 0·6545 |
| 2¾ | 0·03491 | 0·7200 |
| 3 | 0·04215 | 0·7854 |
| 3¼ | 0·04942 | 0·8508 |
| 3½ | 0·05797 | 0·9163 |
| 3¾ | 0·06720 | 0·9818 |
| 4 | 0·07590 | 1·0472 |
| 4½ | 0·09757 | 1·1781 |
| 5 | 0·1205 | 1 3090 |
| 6 | 0·1754 | 1·5708 |
| 7 | 0·2426 | 1·8326 |
| 8 | 0·3208 | 2 0944 |
| 9 | 0·4072 | 2·3562 |
| 10 | 0·5016 | 2·6180 |

the smaller, the larger cylinder would, if supplied with the steam direct, give the same power with the same degree of expansion as all the cylinders together, or in practice, on account of the losses of pressure between the cylinders, a trifle more. The only difference would be in the distribution of the forces throughout the revolution and in the strains on the working parts. It is, therefore, an error to start with the small cylinder in cylinder computations; the large cylinder must be made right for the power and other considerations determine the size of the small one.

The mean pressure, therefore, in all cases, should preliminarily be "referred to the large cylinder," which simply means that there is to be added to the mean pressure in the large cylinder the mean pressure in the several smaller cylinders, multiplied for each by its size relative to the large one. For instance, if the area of the large cylinder be considered unity, and that of the small cylinder of a compound engine be ¼ of that of the large, and there be a mean pressure of 50 pounds in the small cylinder, this 50 pounds multiplied by the relative size, viz., ¼, gives 12½ pounds as the equivalent mean pressure in the large cylinder, which added to that actually existing in the large cylinder, say 12½ pounds, makes 25 pounds mean pressure "referred to large cylinder." The mean pressure referred to the large cylinder used in most of the low pressure engines and in the earlier forms of compound engines was from 18 to 20 pounds. The writer raised this to 25 pounds in designing the engines for the revenue steamer Rush in 1873, before compound engines were introduced in the English or American naval steamers, and thereby obtained good results, for the reason that the mean temperature of the metal of the cylinder was raised and there was less cylinder condensation than when more expansion was attempted.

It will be found, assuming any sizes desired, that the horse power with 25 pounds mean pressure, in any given case, may be obtained by multiplying the piston development by 0·1091, say ordinarily by 0·11, when, of course, the power for a mean pressure of 30 pounds may be obtained by adding ⅕, or the power for a mean pressure of 20 pounds in the cylinder by subtracting ⅕, and so on, in an evident manner. Conversely, if the horse power be determined in advance the first step is to obtain the piston development, which for a mean pressure of 25 pounds is done by multiplying the horse power desired by 9·168.

In general the displacement equals 229·2 times the power divided by the mean pressure. Having obtained the development and decided the number of revolutions per minute from the size of screw or other considerations, by dividing the development by the proposed number of revolutions per minute the result will be the development per revolution, which divided by twice the proposed stroke in feet will give the area of the piston in square feet, from which the diameter may be readily obtained and reduced to inches. If this diameter be too large or too small, the stroke or revolutions may be varied to bring the engines to an ordinary proportion. By this method, the roundabout system of calculating the power with assumed dimensions and then modifying some dimension until the proposed power is procured by a system of approximation is almost entirely avoided. It may here be observed that this preliminary calculation is an important one. It may spoil the good working of an engine if the cylinder comes out an odd inch in diameter to make it an even one; for instance, to make it 30 inches when the calculation gives 29 inches. If a 30 inch engine be desirable for the reason that patterns are available, then for a given boiler power the displacement should be maintained by increasing the pitch of the propeller. It is too commonly the case that an engineer, after making very careful calculations of the size of the engine, considers that he will get a little more expansion and adds to the size of the cylinders. The extreme of this kind of designing is that an elephant must be fed to the work of a horse, so if the first premises were correct, they should be adhered to, as any material departure therefrom will make it hard for the boiler to furnish steam, and cause loss instead of gain. This has been determined in engines of all classes, operating mills as well as driving the propellers of steamers, and is a common experience even on locomotives. The problem reaches its perfection in the design of high speed engines for the Atlantic service, where the difference of trips requiring several days is counted in minutes. Modern designers are very careful not to get the engines too large to work off the steam, and in the construction of the latest great ocean racers the error was on the other side, as it was found, when the cut-offs on small cylinders were set at the point desired, the engines would not work off all the steam the boilers would make, so that not only on the Inman steamers City of New York and City of Paris, but on the new steamer Teutonic, of the White Star Line, the propellers have had to be made with less surface to permit the engines to run a little faster, so that they could develop the power which could be furnished by the boilers.

In technically "getting out of an engine" all that is

possible, the throttle valves should be wide open and the supply be controlled entirely by the cut-off gear. When it is necessary to shut the throttle partially to keep up the pressure, it is an evidence at once that the engines and boilers are not proportioned to work together. Recurring to our previous illustration, multiplying 600, the proposed horse power, by 9·168 gives 5,501 cubic feet as the displacement, with 25 pounds mean pressure, or 3,667 cubic feet for a mean pressure referred to large cylinder of $1\frac{1}{2}$ times 25 or $37\frac{1}{2}$ pounds. If the power is to be developed in a twin screw vessel, the displacement for the higher mean pressure should be 1,834 cubic feet for each engine. If the stroke be fixed at 20 inches, the double stroke would be 40 inches or $3\frac{1}{3}$ feet. If we fix the speed of the engine at 150 revolutions per minute, the piston speed would be $3\frac{1}{3}$ times 150 or 500 feet, and the displacement (1,834 cubic feet) divided by the piston speed (500 feet) gives 3·668 square feet as the area of the large cylinder, corresponding very nearly to 26 inches in diameter. The proper size of the small cylinder depends upon a variety of conditions. If it be desired, from simplicity, to use the link motion valve gear on both engines, the engineers will rarely cut off at less than $\frac{5}{8}$ stroke in the small cylinder, so to obtain an expansion of six times the proportional area of cylinders must be 1 to 3·75 or 1 to 4, though 1 to 3 would be better if the main valve be properly constructed, so that the engine works smoothly when cutting off shorter. A better distribution is secured by using an independent cut-off on the small cylinder and obtaining more expansion in that cylinder, when it will be found necessary to make the small cylinder say $\frac{4}{10}$ the area of the large for pressures of 70 pounds to 80 pounds and about $\frac{1}{3}$ the area of the large for pressures of 100 to 120 pounds. With engines up to 20 inches diameter of cylinder, plain slide valves can be used to advantage on both cylinders. For larger cylinders, the throw of the main valves becomes so great that it is desirable to use a double-ported valve on the large cylinder and continue to use a single valve on the small until it gets above 24 inches in diameter for steam pressures of 80 pounds and up to say 20 inches in diameter for higher steam pressures. The present practice is to use slide valves on the large cylinders in all cases, although for a time it was modified by using from two to four piston valves. Piston valves are now employed almost universally on the small cylinders of triple compound engines and generally on the intermediate cylinders.

In designing a vessel, it is necessary, as at first intimated, to know preliminarily the aggregate weight of the several portions of the machinery which are so compactly arranged that they can be considered as independent masses, so that the machinery as a whole may be placed in the vessel in a position to balance the hull on the water, so that it will "trim" properly or draw the required amount of water both forward and aft. In doing this it is customary to consider as one mass the boiler, which is supposed to be concentrated at its center of gravity a little nearer the front than the rear, on account of the weight of the steam chimney; the engines without the line shafting as another mass supposed to be concentrated at the center of the engine; the line shafting, as another mass supposed to be concentrated at the center of its length; and the stern shaft, with the stern pipe, stuffing box, and stern bearing, as another mass supposed to be concentrated at the common center of gravity a little abaft the center, on account of the increased weight of the stern bearing; and, finally, the screw propeller as still another mass concentrated at its center. These several masses are to be multiplied by the distance of the center of gravity of each from any fixed point, for instance, the after edge of the stern post (or to avoid minus signs, the center of propeller or even the bow of the vessel), and the sum of these moments divided by the sum of the gross weights, which will give the distance from the point of reference at which the center of gravity of the several masses is located. The center of gravity of the hull may in a similar manner be determined by ascertaining the weight of different cross sections, taking the moments of the same from a fixed point and dividing by the total weight as before. The weight of the machinery as a whole, considered concentrated at its center of gravity, and the weight of the hull as a whole, considered concentrated at its center of gravity, may then be multiplied by their distances from a fixed point and divided by the gross weights of the hull and machinery, thereby giving the position of the center of gravity of the vessel as a whole, which, if located at the center of displacement of the hull when in proper trim (by shifting the position of the machinery as a whole or of other weights), will cause the vessel to trim properly. There is frequently great carelessness in this part of the work, as some so-called naval constructors try to average up the weight of the hull by figuring simply a central cross section without taking into consideration the increased weight of the stern of most vessels. Frequently also there is carelessness in distributing the several items of weight in the machinery; but errors in draught and trim occur more frequently from the fact that the vessel is designed piecemeal, the spaces assigned arbitrarily without consideration of the weights to be carried, and the machinery put in where it is convenient, so that the result in the end is quite unsatisfactory, frequently resulting in causing the vessel to be "down at the head" and occasionally at the stern, and requiring that, for the whole life of the vessel, considerable quantity of ballast be carried to "trim ship." Too frequently the weights are not all known in advance, and one thing after another is added until, as a final result, the vessel draws much more water than was at first anticipated. Such defects occur both in merchant and naval vessels, but can be prevented by making originally a complete plan of all the principal parts and a list of all the articles to be put in the vessel, writing opposite each article its estimated weight, when the results of errors on individual items will be less than if the same were left entirely out of consideration.

The weights of the different items of machinery can be obtained, of course, by first making complete designs and taking each up separately, and working out the weight in detail. Such an operation requires a great deal of time, and will even then not be strictly accurate unless the machinery is finally constructed exactly in accordance with such plans. In designing the smaller government vessels it has been found necessary to obtain the weights approximately from a formula, making rather liberal allowances for the difference in design of different manufacturing establishments. A good approximation of the weights of cylindrical or Scotch boilers, 9 to 11 feet in diameter, to carry 40 to 60 lb. of steam, can be obtained from the following simple formula:

| | |
|---|---|
| Approximate weights, independent of water | $W_1 = 44·3\ d^2 s$. |
| Weight of water | $W_2 = 25·7\ d^2 s$. |
| Approximate total weight | $W_3 = 70·0\ d^2 s$. |

The first calculation includes the weight of grates, man hole, plates, smoke pipe, floor plates, and all appurtenances, and the result is, therefore, much greater than can be obtained from calculations from the drawing of the boiler. The formula should be distrusted, except for the particular conditions, and is approximate at the best. For a yacht, by careful design, the miscellaneous weights indicated above can be greatly reduced.

Formulæ for the weights of engines exist in nearly every manufacturing establishment. An old form of equation was: $W = A\ (d^2 s)^{5/6}$.

The weight of some fore and aft compound engines designed by the writer for small sea-going steamers, including surface condenser, valves, pipe, shafting, propeller, and all engine details, was represented by the results from this formula with A=92.4. The dimensions of the large cylinder only were considered, the coefficient being sufficient to include the small one. Similarly the complete weight of a single engine for 40 lb. steam pressure was represented by the results from this formula with a coefficient of 75. The rule is based on the supposition that the standard weights in large engines are not as great as in small ones, and this was undoubtedly the case in the old practice. The writer has, however, found that large modern engines are being worked harder than formerly, and are being made heavier in proportion. So of late he has used a coefficient in units of $d^2 s$ without the modifying exponent. The following examples, derived from actual practice, may be made the basis of obtaining approximate weights for entirely similar parts of substantially the same size, d and s referring to the diameter and stroke in inches. The diameter of the large cylinder only is used for a compound engine.

| | |
|---|---|
| Weight of double 15" x 15" engine without condenser or pump | 4·03 $d^2 s$. |
| Weight of single 36" x 36" engine, with surface condenser, shafting, and propeller complete—light | 2·08 $d^2 s$. |
| Do do—heavy | 2·58 $d^2 s$. |
| Weight of compound engine, 24 and 38 x 27 complete | 2·75 $d^2 s$. |

Weight of heavy cast iron propellers, 6 to 9 feet in diameter, in pounds, 48 to 52 times the square of the diameter in feet.

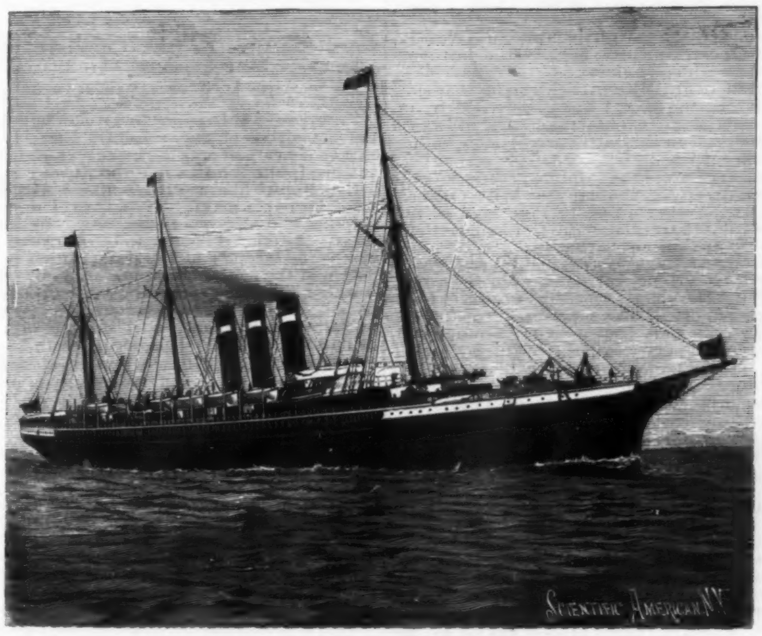
Weight of jet condenser, 2·6 pounds per square foot of heating surface of boiler.

Weight of surface condenser in engine frame, 7·8 pounds per square foot of heating surface of boiler, or 13 pounds per square foot condensing surface.

It should be recollected that formulæ of this kind are only adapted for the particular conditions. Machinery designed for the smaller government steamers is very much heavier in proportion than that employed for steam yachts, and particularly heavier than that used for torpedo boats. It is necessary to provide for the revenue cutters machinery which is reliable and operates at such moderate speeds that it needs but little attention. There is produced by the machinery of the larger cutters 4 to 5 I. H. P. per ton of weight, which compares well with the examples given for the English navy, considering the fact that small machinery of a given type, with an equal number of details, must in general weigh more than larger machinery. A cutter was, however, recently designed in which $7\frac{1}{2}$ horse power were to be produced per ton of machinery, or about the same as in the average practice in very much larger steamers, but to do this it was necessary to use a special patented boiler. The precaution was taken of trying one of these boilers in a smaller vessel, and, although the same size had operated well in steam yachts, it gave so much difficulty under the conditions of government duty that it has been decided to lengthen the new vessel in order to carry the increased weight of cylindrical boilers of ordinary type. In designing machinery for yachts the owner should be told that greater speed can be obtained by using lighter types of machinery, but that it would involve more skillful engineering to operate it and more frequent repairs, that he may judge whether or not he will, in a certain sense, make his vessel a workshop, or be satisfied with slower speed to secure a type of machinery that will require less attention.

In preparing this lecture it was at first expected to state some of the rules used by the speaker in determining the sizes of the various parts of steam machinery, and to call attention to some precautions necessary in the preparation of specifications and contracts for marine construction, but the general consideration of the subject has occupied so much time that these further details must be omitted.

The most remarkable examples of high speed engines, when size is taken into consideration, are those of the new steamers of the Inman line built in Great Britain, but practically owned in America, the City of New York and the City of Paris. There are in each ship two triple compound engines driving twin screws, each engine provided with three cylinders, respectively 45 inches, 71 inches and 113 inches in diameter with 5 feet stroke of pistons. The steam pressure is 140 pounds, and these engines have been driven continuously from shore to shore across the ocean at an average of over 86 revolutions per minute, or at a piston speed of 860 feet per minute, developing collectively an average of nearly 19,000 horse power. The writer had the pleasure of being on the fastest ocean trip ever made, viz., that of the City of Paris, completed August 29th, 1889, in which the time between Queenstown entrance and Sandy Hook light ship was five days nineteen hours and eighteen minutes. The engines were not stopped throughout the entire voyage, except to take on board the pilot, which occasioned a loss of 15 minutes, included in the total time. The speed occasionally fell to 83 revolutions per minute when cleaning fires, but soon afterward ran up to 88 and 90 revolutions, thus making the average as high as that previously stated. There is nothing so much impresses a steam engineer as to see engines of this size running at the speed referred to. The weight of the cranks and connections amounts to tons instead of pounds, and the distances moved through in changing the masses from one portion of the stroke and revolution to another are absolutely startling to those who think that number of revolutions fast even with engines of a few hundred horse power. The successful operation of engines of this size at such a speed and at such a steam pressure is the most marked development of the progress in the construction of steam machinery, and reflects great credit upon the builders and the engineers in charge. At such steam pressures all joints must be absolutely perfect—by no means a simple matter in castings of such great size; the material must be the best that can be fabricated, and fully equal in unit strength to that of smaller pieces, a result not heretofore accomplished to any great extent except in the manufacture of heavy ordnance; and the tendency to heat and unduly wear the bearings has only been prevented by the employment of special compositions containing some of the new metals recently added to those available for the use of the mechanic, which compositions have been found by trial to run cool with heavier pressures and at higher velocities of the moving surfaces than others heretofore available. The difficulties attending the problem are emphasized by the fact that the City of New York, which is the duplicate of the City of Paris in every particular, has not yet, after running two seasons, been brought up to the speed of the City of Paris. It is claimed that there are no radical defects, but that the little difficulties which are continually happening with steam machinery have occurred and recurred at such intervals that the average speed is far behind, and the best trip made is only about the same as the best ones of the Cunard steamers, constructed several years ago, although Mr. E. J. Gearing, the former outside superintendent of the builders who fitted out the City of Paris, and remained with her until she had beaten the record, was early this season transferred to the City of New York. We have just learned that this vessel on her last trip, from New York, broke the crank pin of one of her engines, the third day out, but kept on with the other. She made 433 and 434



THE STEAMSHIP CITY OF PARIS.

miles per day the two full days before the accident, and made with one engine 375, 382, 352 and 316 miles during the four full days afterward. The round trip under these circumstances was made in 7 days and 56 minutes. The results show the great advantage of having duplicate machinery throughout, as, notwithstanding the accident, the vessel was not only entirely safe, but lost less than a day's time.

The uncertainty involved in attempting these high speeds is shown by the fact that the Teutonic, the first of the new vessels of the White Star line, which it was expected would greatly outstrip all rivals, has not yet proved herself superior in speed to the Etruria and Umbria of the Cunard line, and although she has occasionally done better than the City of New York, she is still far behind the City of Paris. The machinery of the Teutonic develops less power than that of the City of New York or the City of Paris, the builders evidently depending somewhat upon the shape of the hull, which is longer and narrower than those of the new Inman steamers. The speaker believes that the chief difficulty is with the amount of power applied, and that the slight differences which can be obtained by changes in models, already good, can have no appreciable effect on the result. A view of the City of Paris, the queen of the sea, is now shown on the screen, and by the courtesy of the agents of the line, you will have an opportunity, on dispersing, to see a lithographic view of the same vessel, which, at our request, has been courteously presented to the college by the New York agents of the company, Messrs. Peter Wright & Sons. In closing, we desire to thank all present for kindly greetings and earnest attention.

## IMPERIAL STACK PRESSES.

WE illustrate two forms of manual stack presses invented by Mr. H. C. Tucker, of Banbury, Eng. In Fig. 1 it will be seen that the pressing frame is capable

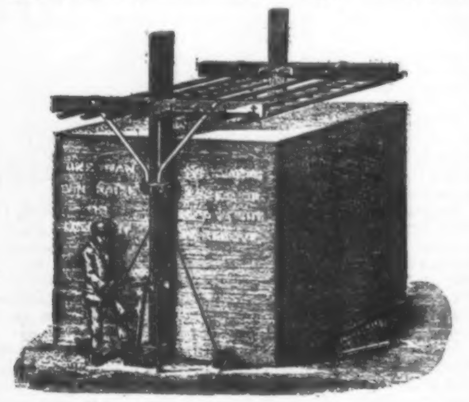


FIG. 1.

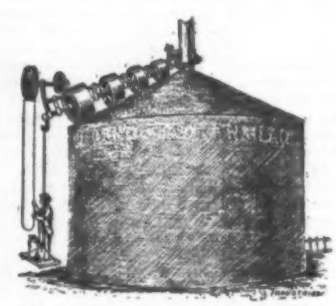


FIG. 2.

of sliding vertically on the two upright standards, and that it is pressed down upon the stack by means of the screws and hand levers. The frame consists of two beams and of transverse pressing rods, which can easily be removed to allow of the addition of further supplies of grass or hay. In Fig. 2 we show a revolving apparatus for forming circular stacks. It consists of an inclined axle which carries the pressing wheels, and which is attached adjustably to the central upright pole. The end of the axle carries a platform for the man and for an additional weight, and a gearing is provided as shown, by means of which the man can make the apparatus roll round the stack.—*Industries.*

[Continued from SUPPLEMENT, No. 733, p. 11712.]

## LIME SULPHITE FIBER MANUFACTURE IN THE UNITED STATES.

By Major O. E. MICHAELIS, M. Am. Soc. C.E.

### COOKING.

"COOKING," or the treatment of the wood with calcic bisulphite to obtain cellulose, is fully explained by Mr. Griffin. I will merely dwell long enough upon this branch of the subject, therefore, to make my own impressions clear.

There are two methods pursued, a quick and a slow process, applying the words merely to time, and not to output. The first process, which is not under patent protection, is pursued in all the digesters except the Mitscherlich; the second, covered by an American patent, is peculiar to the Mitscherlich.

The quick process requires for a boil strong liquor, high pressure, short time, and yields a small product. The slow process requires a weak liquor, low pressure, long time, but yields from four to eight times greater a product.

The Mitscherlich, aside from every other consideration, appealed to me as being logical and precise; the other struck me as inconsequent and unscientific.

In the Mitscherlich process, the cooking is done by indirect heat, steam pipes; in the other, by direct heat, the condensation of steam. Hence the former method uses a liquor of uniform, the latter one of constantly varying strength. To illustrate, 2,600 gallons of strong liquor entered the Graham digester, a "quick" boiler, 2,000 gallons of condensed steam are added during cooking.

At one quick method plant we learned that it was frequently necessary to add strong sulphite solution while the boiling was actually going on.

If warm baths were prescribed for a patient, I imagine he would protest vigorously against being immersed in boiling water, even if assured that the cold water had been turned on. The application is readily seen.

The quick process, as we gleaned from inquiries at the various plants where it is carried on, requires from fifteen to twenty-four hours for boiling; the Mitscherlich, as shown by the Alpena experience, from forty-five to seventy-two hours. It will thus be observed that the range of variation, 60 per cent., is precisely the same for both processes. It was noticeable that in certain cases the best possible conditions of time, temperature, etc., of the quick process were compared with the most unfavorable showing of the slow.

This matter of time is apt to be misleading. The best claimed showing was made by the Graham expert, nine complete "turns" per week, or a single turn in about eighteen hours, producing 1½ tons of fiber.

The best figures for the Mitscherlich are a complete turn in seventy-two hours, producing nearly ten tons of fiber—four times as long, with over six times the output.

In the Mitscherlich procedure, one operation impressed me as grotesquely un-American. The cooked fiber is washed for ten hours in the digester. This great money-coining apparatus is compelled, for over one-tenth of its time capacity, to function as an ordinary washing engine. This is simply an accidental part, in my judgment an evidence of bad business management; yet the opponents are not slow in arguing, from the condition imposed by this ill-judged operation, against the whole method.

As cold water is used in this washing, they claim that the temperature of the Mitscherlich digester fluctuates from 40 to 270 degrees Fahr., a range of 230 degrees, while in their process the temperature never falls below 150 degrees, thus giving a range of only 150 degrees.

This objection is met by an obvious practical remedy, saving time and consequently money—the introduction of separate washing engines.

In confirmation of Dr. Mitscherlich's claim that slow boiling affords a better fiber, I have been told by an experienced soda pulp manufacturer that it was a well-known fact that in this latter process slow boiling yielded a better output.

It is singular that while the sulphite process was the invention of an American, Germany made it a practical success. We are now beginning to take hold of this American idea, but burdened with German methods and incrusted with Teutonic barnacles.

The most complete quick process plant I saw was at Cornwall; here everything, including even the assembled digesters and the gauges recording pressures in *atmospheres*, was imported. The superintendent told me that he thought the best course had been pursued, that they had the necessary experience abroad, and so on, and yet I noticed he was modifying his apparatus about as rapidly as he could.

The German adjuncts and methods at Alpena had to be entirely thrown aside, and apparatus and operations developed in our own paper-making industry have been introduced. There is a reason for all this; in Germany labor is phlegmatic, inexpensive. I have been told that women sort and inspect chips for twelve and a half cents per day, and of course they have none but wooden ideas. As a consequence, the German manufacturer, absorbing the phlegm of his employes, has both perseverance and patience.

We are quick-witted, we have abundance of perseverance in attaining our ends, but precious little patience in waiting for results. To this I ascribe, in a measure, the allurement which the quick process has for us. We hug the delusion to our hearts that we can produce ten tons just as quickly as one and a half, and mentally eliminate all intervening insurmountable difficulties.

The most German of all processes is the Mitscherlich, yet I firmly believe that with American business management and American engineering skill, it can be rehabilitated as a genuine American method.

It is idle to catalogue the ponderous, painful steps that still characterize it; there is not one that could not be practically improved. The disks, for instance, are really fed, piece by piece, into the digester; they should be automatically shoveled in by the cart load.

Astonishing as it may seem, the German engineers turned over the first completed plant and acquiesced in its being run by an energetic American, utterly without experience, who at the same time superintended two sawmills producing annually some forty million feet. It recalls poor Colonel Sellers' "little side speculations."

To attain the best results, the head of the plant should be a sterling business man, interested pecuniarily in its success, aided by competent assistants in the technical, chemical, and engineering departments.

NOTE 1.—It may be of interest briefly to investigate the stress to which the lead coating in the Graham digester is subjected by change of temperature.

The linear coefficient of expansion of lead is 0·0000158
Its modulus of elasticity.... .................. 720,000

A range of 200 degrees is a very moderate assumption for this process, for it boils at over 300 degrees.

We have, then, the stress $p = 0{\cdot}0000158 \times 720{,}000 \times 200 = 2{,}275$ pounds.

The elastic limit of lead is given by Trautwine as 1,100; we see, therefore, that, even after making due allowance for the expansion of the iron shell, the fixed lead is strained beyond its elastic limit. Every plumber, from his own experience, can tell what will result.

NOTE 2.—Mr. Griffin's analysis of the Schenk boiler metal gives:

| | |
|---|---|
| Copper | 91·28 |
| Tin | 7·68 |
| Zinc | 0·89 |

In 1877 the British Admiralty determined the effect of heat upon the kalchoid alloys of copper (see *Engineering*, October 5, 1877).

"The metal was cast in the form of rods one inch in diameter, and composed of five different alloys, as follows:

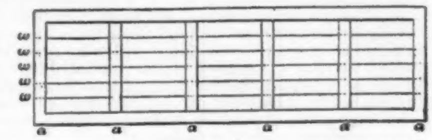
. . . . . . . .

"No. 2.—Copper, 91; tin, 7; zinc, 2. (The nearest approach to the Schenk mixture.)

"The specimens were heated in an oil bath near the testing machine, and the operation of fixing and breaking was rapidly and carefully performed, so as to prevent, as far as possible, loss of heat by radiation. At 100° Fahrenheit the strength and ductility of the above test piece was 525 pounds and 15·5 per cent. At 300° Fahrenheit the strength was 265 pounds, the ductility *nil.*"

I cite this as confirmatory of my statement regarding the sensitiveness of these alloys.

NOTE 3.—"It is but fair to add here that Professor Langley has observed that acids and the fumes of his laboratory will change the very structure of metals. He had in his laboratory a frame of the following form:




"The wires, *w*, of copper, brass, and German silver, were run through the crossbars, *a*, which were of wood, about 2 inches wide. After three years he noticed the wires breaking, and upon examination he found them to be coarsely crystalline, brittle—in fact, rotten, and entirely changed in structure. He found also that the parts that were in the wood, and so protected from the fumes, were soft, ductile, and entirely unaffected. All of the exposed wires were affected similarly, and all the protected parts were equally unaffected, except the copper wire, which was stiffened, but not materially changed in structure."*

## SOME REMARKS ON THE CHEMISTRY OF THE PROCESSES OF LIME SULPHITE FIBER MANUFACTURE.

By MARTIN L. GRIFFIN, M.A.

I propose in this paper to give an outline simply of the chemistry of the sulphite fiber industry. This will be concerned only with the material for digesters, the bisulphite solution and the fiber.

By sulphite fiber is meant fiber manufactured from wood for paper making by the use of a solution of bisulphite of lime or magnesia. As you are doubtless aware, the chief difficulty to be overcome in this process is the securing of a digester which will stand the action of the acid solution used to reduce the wood to fiber. I will first explain the composition and nature of this acid liquid. Sulphurous acid gives two classes of salts, like carbonic, the bisulphite and the neutral or normal sulphite. The normal sulphite of calcium has this formula, $Ca\,SO_3$, while the bisulphite requires two molecules of the acid radical giving twice as much sulphur, and expresses thus:

$$Ca{<}\begin{matrix}O\\O\end{matrix}\begin{matrix}H{>}S{=}O_2\\ \\H{>}S{=}O_2\end{matrix}$$

The former is only soluble in 800 parts of water, though freely soluble in aqueous sulphurous acid, thereby becoming the bisulphites. To obtain the solution desired for the manufacture of sulphite fiber we should require for each part of calcium (the ratio of calcium to its oxide, lime, being as 5 to 7) 3·2 parts of sulphurous acid gas or 1·6 parts of sulphur.

This acid solution is made in two principal ways, and in all cases the sulphurous gas is produced from burning sulphur in retorts to which only a limited supply of air is admitted. The gases are either received into tall towers, as in the Mitscherlich system, where it is absorbed by porous limestone over which water trickles downward, meeting the ascending gases; or it is absorbed directly into a solution of milk of lime by the aid of a vacuum pump. This is known as the vacuum system. In the former case the sulphurous gas displaces the carbonic, thus: $Ca\,CO_3 + SO_2 = Ca\,SO_3 + CO_2$, and we have the bisulphite solution flowing off. In the latter there is no gas to be displaced, the reaction being $Ca\,(O\,H)_2 + SO_2 = Ca\,SO_3 + H_2O$. By this process a solution of any desired strength can be made.

It may seem to be a very simple operation to burn sulphur to sulphurous oxide; but in reality great care is required, since by the admission of too much air to the retorts, sulphuric oxide may be formed. This uniting with the lime forms insoluble sulphate of lime, which in the Mitscherlich towers would form a coating over the limestone and cause a variety of troubles. In the vacuum system it would form an inert deposit, causing a waste of lime and sulphur.

An excess of air will cause the sulphur to burn more rapidly, thus developing too much heat, which facilitates the formation of first lower, then higher, polythionic acids, then sublimed sulphur. These acids are all sulpho acids, having an increasing proportion of sulphur. They not only cause a waste of material, but exert injurious effects upon the quality of the fiber. They also cause a fictitious strength of the liquor, which cannot be detected by the ordinary workman.

When we reflect what a peculiar substance sulphur is, and how easily its chemical and physical properties are changed, we cannot wonder that it should cause difficulties in any process in which it is used. At the ordinary temperature sulphur is a light colored, brittle solid; at 115° C. it melts to a thin amber liquid; heated to 250° it becomes dark colored and thick; at 450° it boils and passes off as a dark colored vapor. These changes in its state of aggregation are due to changes in the molecule, which varies in the number of atoms it contains, according to the temperature. At 1,000° and above it consists of two atoms, at 500° it consists of six atoms, and at lower temperatures it

* Steel: its Properties; its Use in Structures and in Heavy Guns. William Metcalf, M. Am. Soc. C. E., Trans. Am. Soc. C. E., vol. xvi., p. 291, June, 1887.

probably contains a still greater number. This peculiarity makes possible a great variety of sulpho-acids and salts. Sulphur is one of the most useful, powerful, and peculiar elements with which chemistry deals. Its gases are pungent and penetrating, and its acids the most powerful and corrosive, forming a most stable class of salts. A very small fraction of one per cent. in metals renders them useless, and it exerts injurious effects even in the smallest proportions.

Is it any wonder, then, that we should meet with difficulties in finding a material for sulphite digesters? Practically there is only one metal yet discovered which withstands the action of sulpho-acids fairly well; it is lead. A substance very rich in silica is the only mineral. These two kinds of material are all that have accomplished much so far in the construction of sulphite digesters. There are, however, digesters of bronze in operation for which success is claimed. I will now briefly describe those which are doing a representative business.

The Mitscherlich is 14 feet in diameter and 40 feet long, holding about twenty-five cords of wood when cut up into disks 1¼ inches thick, and produces at each "turn" 12½ tons of dry fiber. It is composed of a wrought iron or steel shell ⅝ inch thick, which is first coated with pitch or tar within. Upon this is laid a continuous layer of very thin sheet lead; next comes a course of bricks specially made for this purpose, each having a tongue and groove, which are laid flatwise in the best Portland cement. Upon these is laid another course of bricks edgewise, having their tongues and grooves arranged accordingly. Each digester is stationary and placed horizontal.

The Schenk, a bronze digester, has the following composition:

| | Per cent. |
|---|---|
| Tin | 7·68 |
| Copper | 91·28 |
| Zinc | 0·89 |

The specific gravity of a small casting was 8·5579; the computed gravity is 8·76. The specific gravity of copper is 8·94. These figures will indicate the difficulty in making perfect castings of copper alloys free from combined and occluded oxygen. Hence it follows that the larger or more numerous the molecular interstices, the more surface is exposed and the more permeable is the metal by gases, and so more affected. All metals are susceptible to this influence to a greater or less extent. A very marked illustration of the absorption of gas by a metal is observed in the case of palladium, which absorbs 376 volumes of hydrogen at the ordinary temperature.

According, therefore, to the nature of the gas, the metal, and the temperature, will various results be observed. I am personally cognizant of a case where lead, under the influence of sulphurous acid gas, has been changed to a salt of this acid. Similar instances are recorded of copper and other metals. Copper when plunged into molten sulphur is immediately changed to the sulphide of the metal.

At the present time we see several manufacturers of bronze claiming that they have an acid proof alloy, but no reputable chemist can entertain such an idea for a moment. Neither is any copper alloy proof against the action of sulphurous and sulphuric acids, in any proportions. The effect of these acids on digesters of copper alloys is, first, to dissolve a little from the surface, which is immediately reduced to the oxide and sulphide of the metal by the reducing power of the organic matter dissolving from the wood. This soon forms a black coating on the interior, which is continually crumbling off by the expansion and contraction of the metal, thereby contaminating the fiber with black specks. As regards the life of such digesters, it is simply a question of the rapidity of the action of the chemicals and the thickness of the metal. It is not improbable, also, that the scale affords some slight protection to the metal.

We have now left for our consideration digesters lead-lined in different ways and of different shapes.

The Ritter-Kellner digester is vertical and stationary, about 10 feet in diameter and 28 feet high, made of wrought iron or steel, 1 inch thick. The interior is lined with sheet lead half an inch thick. This is attached to horizontal and vertical tenons of lead and antimony dovetailed into the seams. This gives an opportunity for expansion of the lining in sections. The ratio of the expansion of iron to lead is a little less than 1 to 3. As the digester is repeatedly heated and cooled, there must be a recurring movement back and forth from the shell, or else the lining must "buckle." This movement, in time, is sufficient to produce cracks, which then must be repaired. This coincides with experience.

The Partington digester is spherical and rotates upon an axis. It is built of iron or steel, and the lining of lead is attached in lunes by the use of leaden headed bolts and clamps. This form of attachment has caused more trouble than the others, as the bolts and clamps have offered greater inducements for the liquor to penetrate to the shell, thus requiring more time for repairs by their frequency, and the extra exposure of the shell to injury.

The remaining digester to be described is the Graham. It may be built of any shape or size, stationary or rotary. The chief difference worthy of notice is in the attachment of the lining. In plain language, the lead is soldered to the iron or steel sheets by the aid of chloride of zinc. They are then rolled cold and assembled. The seams are polished and filled in with lead by means of an autogenic apparatus.

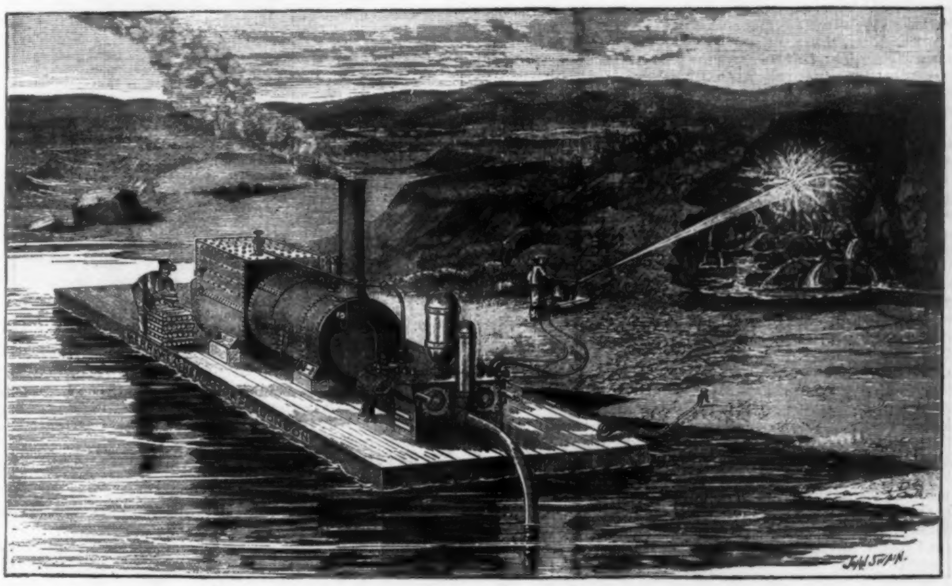
The cellulose prepared by all the acid processes contains a considerable quantity of incrustating matter and lime salts, and hence is harsh and brittle. When a magnesian base is used, it is claimed that a softer fiber is produced; personally I cannot see much difference. When the pulp is first removed from the digesters it is beautifully transparent, owing largely to the powerful bleaching effect of the sulphurous gas, which acts as a deoxidizing agent. Papers made for service for any length of time should be reoxidized and bleached with hypochlorite of calcium. If this is not done, the paper soon assumes a yellow color from exposure to light and air.

The conclusions, therefore, which we draw are: That from a scientific standpoint only two kinds of material are admissible for sulphite digesters. Each must be supported by means of an iron shell. In the one case the lead lining expands much more than its stronger companion, is therefore subject to a great stress, which in time will produce fissures and crystallization, and is permeable by the sulphurous gas, which has a tendency in addition to produce hardness and brittleness. In the other case the brick or tile lining expands much less than the iron shell, and so this is liable also to crack if a temperature above 118° C. is reached.

A plant under either of these systems may be successful by good management, nevertheless, without which no enterprise can succeed. Sulphite fiber fills a much needed place in the manufacture of paper, and is and will continue to be profitably made.—*Trans. Amer. Soc. Civil Engineers.*

## HYDRAULIC GOLD FINDER AND IRRIGATOR.

MERRYWEATHER & SONS, of London, have brought out the hydraulic gold finder which we illustrate. The machine consists of one steam pumping engine, with boiler, arranged on a raft, and with a monitor for directing the stream of water by means of which the gravel is washed. The machinery can, of course, be fixed in any other manner than in that shown, and is able to take its suction from any depth down to thirty feet, and to force the water to a height of 250 feet above its own level. With a little different arrangement the engine can be used for the irrigation of plantations of various kinds, or for watering plantations by means of an artificial rain. An engine of the class is being constructed, to be fixed on an iron punt, for use on a sugar plantation. The punt being of very light draught will travel through the canals on the plantation, and a stream from the engine will be used to propel the punt through the water, at the same time that another jet is thrown into the air, and distributed as artificial rain. The use of engines of this class in the colonies is practically unlimited. In some parts, where the transit of heavy machinery is almost impossible, and in any case is most costly, so that waterworks pumping engines of the usual description cannot be employed, an engine of this type, with its wheels removed, has proved itself to be a very efficient substitute, and the whole expense has been less than heavy waterworks machinery would have cost for transit alone. In South Africa engines of this kind have been employed in furnishing a water supply for railway purposes, and have proved themselves to be very valuable, especially when it has been found necessary to transport them across country.—*Iron.*



HYDRAULIC GOLD FINDER AND IRRIGATOR.

## THE BERLIN EXHIBITION OF APPARATUS AND APPLIANCES FOR THE PREVENTION OF ACCIDENTS.

By Dr. JULIUS POHLMAN, Buffalo, N. Y.

WHILE the International Exposition at Paris engaged the attention of the civilized world, a more quiet and unpretentious exhibition was held in the capital of Germany—Berlin; and while numberless pages in periodicals and journals have been devoted to descriptions of the former, the latter, although unique, has almost escaped the attention of the American public. True, the Paris exposition was grander, more pyrotechnic display like, Eiffel tower, etc., yet in the amount of absolute good it has done to mankind, outside of financial considerations, it is not saying too much that the mere National Exhibition at Berlin has been productive of more benefits to the human race than the great exposition just closed in Paris.

The "exhibition of appliances and apparatus for the prevention of accidents," recently ended at Berlin, was decidedly instructive from a humanitarian standpoint, and should receive more than a passing notice in the land of machinery *par excellence*, the United States. If we bear in mind that in the German empire, with a—comparatively speaking—limited amount of machinery and ten million so-called laboring men, 136,181 accidents were reported during 1888, resulting in 20,666 cases of death and total disability, any exhibition which aims to bring to public notice all the means known up to date to prevent such accidents, either totally or in part, seems to be not merely humane, but also very decidedly necessary, and worthy of imitation in all countries where machinery is used. As many accidents occur which are never officially reported, it is safe to assume that the above numbers represent the minimum rather than the maximum of all the accidents. If similar statistics could be obtained for the United States, an exhibition like that held during the summer in Berlin would perhaps seem an absolute necessity, and appliances for the prevention of accidents would find a better market than they have now.

The exhibition palace in Berlin is a fine, permanent building, of iron and glass, centrally located and easy of access from all parts of the city. Like everything worthy of notice in Germany, and specially in Berlin, this exhibition was under the "most high protection of his Majesty, the Emperor," which, however, did not in any way injure the usefulness of the undertaking. In a general way it was divided into sections pertaining to accidents on the water, by fire, on railroads, in mines, and by machinery generally.

Strange to say, in a country where the paternal government appropriates to itself the right to do almost everything that is worth doing, the lifeboat service of Germany is a private institution, and supported by membership fees and voluntary contributions. As was to be expected, "The Society for the Saving of Shipwrecked Mariners" had a fully equipped life-saving station on exhibition, together with a series of finely executed models illustrating the work and uses of each apparatus, and even the most indifferent visitor could carry away a fair idea of what is done up to date to decrease the loss of life due to shipwrecks. That on a competitive trial our American "Dobbins" lifeboat will be found superior to those used on the German coasts admits of no doubt, as on the former the full extent of Yankee ingenuity has been expended in the building of a practically unsinkable boat, whereas the latter must always be in danger, no matter how carefully handled.

The Imperial Hydrographic Institute supplemented this exhibit by numbers of beautiful charts, nautical instruments of the most improved pattern, models of simple as well as of light, bell, and whistling buoys. Private firms exhibited models of all kinds of modern vessels, from the 10,000 ton steamship to the small yacht, lighthouse and ship lanterns, among which are electric light night telegraph, invented by Mr. Gustav Conz, of New Ulm, which deserves special mention as enabling correspondence at sea between ships passing each other during the night time. Cork jackets, life-rafts, and diving apparatus in numberless variations completed that part of the exhibition which aimed to show what is known up to date to lessen the dangers of travel by water—ocean, lake, or river.

Next in interest to the main exhibition was undoubtedly a theater built on a hill in the exhibition park. Well knowing the dangers which constantly menace buildings of that kind, and remembering the frightful loss of life in cases when accidents did occur, the managers of the exhibition called to their aid the most competent staff of theatrical builders, architects, and engineers to devise and build, not a *model* theater, but a theater in which all modern appliances to lessen danger and prevent accidents were in actual operation. Built of iron, without boxes and galleries, its seats were all on the ground floor, accommodating 600 people; the stage measured 24 feet by 28 feet. The drop curtain was made of wire gauze filled in with cow's hair; all wings and flies were made of asbestos cloth and other incombustible material. The machines and ropes necessary for the work on the stage were all so carefully covered or run in such a manner that even the most careless visitor would find it hard to be caught by any portion of them. Short ballet performances given three times a day presented not only a fine opportunity for witnessing the scenic possibilities of modern theaters, but also the brilliant light effects made possible by the incandescent electric light in a practically safe theater.

As the principal German railroads are all owned and operated by the State, the government had all their safety appliances on exhibition—air brakes, automatic couplers, switches, danger signals, etc., etc.; construction and wrecking trains, locomotives, freight cars, and passenger coaches were represented in well executed models, these, together with a competent corps of officials to explain and answer questions, gave a good idea of the status of railroads in Germany. Nevertheless, an American's breast must fill with pride when he remembers that, as far as comfort and elegance are concerned, the American railroad is as far ahead of the German as the present ocean racer is superior to the first steamship that ever crossed the Atlantic.

The safety appliances for fires show us a variety of

engine models, from the simple hand pump to the modern powerful steam pump; ladders, large and small, light and heavy; incombustible suits and blankets for the use of firemen when entering burning buildings; respirators connected with air reservoirs carried on the back, to facilitate operations in smoke or gas filled places; appliances to test the power of the engines, the strength of ropes and hose used by the fire departments throughout the empire. When we remember that there are no frame houses in Germany, and that all plans have to be submitted to the proper authorities for approval before building operations can be commenced, we can understand that accidents and destruction of property by fire are less in Germany than in the United States.

The section devoted to accidents in mines commenced in a logical manner by first illustrating the different kind of mines with a series of beautiful large models; then in succession we see elevators and hoists; models of safety rooms where the miner finds protection against fire damp and dust explosions; electric plants for lighting, for drilling, and for the firing of cartridges; dust collectors, ventilators, safety lamps, tools, in fact, everything belonging to a well regulated mine or handled by the miner. Of special interest here is a collection of broken "safety" spectacles, alongside of each of which was placed the piece of stone or metal that broke the glass, and which would have injured the eye seriously, if not permanently, if it had not been protected by these useful spectacles. Models of miners' houses, wash and bath rooms, blast furnaces, cranes, dumps, etc., gave the visitors an opportunity to obtain a fair idea of what kind of accidents can take place in and around mines, and what has been done up to date to prevent their occurrence and what steps have been taken to improve the condition of the miner.

The dangers of boiler explosions were exhibited by the association of steam boiler inspectors. The corroding action of certain waters, and the weak points in boiler plates, due to sedimentary deposits, were clearly brought before the eyes of the visitors by a full series of sections, taken from condemned or exploded boilers; alongside of this we have the different appliances for the purification of the water before it enters the boiler; all kinds of steam and water gauges, safety valves, automatic registers, and electric calls.

Paper mills, flouring mills, beer breweries, all find their place here; in fact, we may say that the rest of the exhibition is merely an exhibition of machinery of all kinds, each one provided with some special appliance to guard against accident, and here large models of a fully equipped planing mill and a complete machine shop deserve more than a passing notice. In both of these models not only every cog wheel, pulley, or belt is covered in or run so that contact is almost impossible, but alongside of each machine there is an electric button, pressure on which not only shuts off the steam but at the same moment clasps a powerful brake to the fly wheel, thereby stopping the whole machinery almost instantly. The value of such an arrangement can hardly be overestimated, for there are many accidents on record where life or limb of the person could have been saved if the machinery had stopped soon enough, but it took some time to notify the engineer and to have the steam shut off, and it took a few additional precious moments before the fly wheel stopped, and then it was too late to save the unfortunate victim of the accident.

A collection of model dresses for factory hands, men and women, attracted a fair share of attention. True, that for women did not in any way have the faintest resemblance to the "divided skirt" or the "bloomer" or similar so-called dress reform articles advocated on this side of the Atlantic; the value of this model dress consisted chiefly in its simplicity and smoothness, avoiding all folds and pleats and what-nots of the ordinary garment.

A woman dressed like this could walk between machinery with perfect safety, because the numberless dangers resulting from unprotected belts and pulleys and wheels would glide over her dress and find no place to take hold and endanger her safety. A smooth waist with equally smooth sleeves and skirt and a simple cap to cover all the hair may not look very fashionable, but it certainly can be made to look neat, and is above all serviceable in protecting its wearer against some of the many dangers that lurk in a hall filled with machinery.

A simple device was adopted throughout the exhibition to direct the attention to the appliances for the prevention of accidents. A non-professional man would naturally experience difficulties in the attempt to discover which portion of the machine he was looking at illustrated the purpose of the exhibition; in order to avoid any mistakes in this line every one of these appliances was painted in a bright red color, and by this simple and efficient means even the ordinary visitor was enabled to locate each protective measure and see for himself in what manner and against which danger the increased security was attained. Whether it was attached to a saw or to a weaving machine, to a grindstone or to a mine model, the red color immediately attracted the eye of the visitor, and from hall to hall the one object of the exhibition was constantly before him.

Of course an exhibition teaching how to avoid accidents would not be complete without a section devoted to emergency cases illustrating what can be done and what has to be done when accidents did happen. Here was found a small hospital, easily transportable and simple of construction; made of light wood and paper, it can be erected at any place in a few hours; a large exhibit of dummy figures showing accidents—bandages, splints for broken bones, made of canes, umbrellas, paper rolls, etc., all well known to the surgeon, but rarely to the general public; stretchers to remove the wounded made of sticks and tools and whatever thing can be found in an out-of-the-way place. The very efficient ambulance corps of the German army had here rendered its valuable aid to make this part of the exhibit as complete as possible, while the Imperial Health Department supplemented it by the exhibition of apparatus and materials for the disinfection of cellars, vaults, rooms, clothing, water, etc., together with a full series of bacteria cultures. In this section twice a week during the forenoon and every second Sunday in the afternoon free lectures were delivered by the most competent men of Berlin upon the subject "What to do in case of accident," and as these lectures were divested of all technical expressions, and the material for their illustration was close at hand, large and intelligent audiences availed themselves of the opportunity so offered.

Very cheap railroad fares were offered by the government railroads to workingmen who intended to visit the exhibition, and many thousands sent there by their employers or by their unions from all sections of the empire must have carried home with them at least a few of the ideas so well illustrated here. Whether the number of accidents will be perceptibly reduced for the next year on account of this exhibition must remain an open question for the present; the universal indolence of the employer as well as of the employe may wait perhaps for the enactment of more laws enforcing some of these safety measures, but whichever way the result may turn, the object of the exhibition was good, and, as a first attempt in that direction, a decided success and well worthy of imitation in other countries.

## NEW ELECTRIC METERS.

THE large increase in central stations for distributing electric energy, during recent years, gives a peculiar interest to the question of electric meters and to the examination of the principles of some recently proposed solution of the problem, which is a simple one in theory, but extremely difficult in practice if we wish the apparatus to realize all the conditions that characterize a perfect instrument and that are often incompatible with each other.

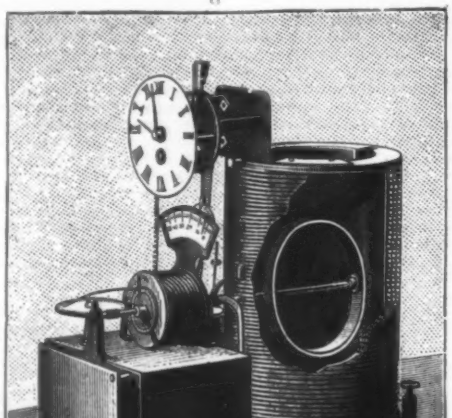


FIG. 1.—BLONDLOT'S WATTS-HOUR-METER.

Let us briefly recall in the first place that the energy furnished an electric apparatus during a given time is a function of three distinct factors—the intensity of the current, the difference of potential at the terminals, and the time of passage of the current.

In the most general case, the three factors are supposed simultaneously variable, and the apparatus then constitutes a watts-hour-meter. When the distribution is of constant potential, the problem is simplified, and the apparatus becomes an amperes-hour-meter, or, as it is oftener called in current language, an electric meter. The four apparatus here represented, and the first types of which figured at the late exposition, are two watts-hour-meters for continuous currents and two amperes-hour-meters for alternating currents.

*Blondlot's Watts-Hour-Meter.*—As in most of the counters of this species, we find two essentially distinct parts—the measuring apparatus and the integrating apparatus. The former of these is an electro-dynamometer whose fixed bobbin with vertical axis is wound with coarse wire and is traversed by the total current furnished to the consumer. The fine wire bobbin placed within the coarse wire one is mounted in derivation between the distribution terminals of each subscriber. The couple exerted upon the movable bobbin by the fixed one is thus proportional to the product, $e$ I, of the intensity, I, of the principal current by the difference of potential, $e$, at the terminals of distribution. A counterpoise arranged upon an arm mounted upon the axis of the movable bobbin balances the electro-dynamic couple and causes a deflection of this bobbin by an angle proportional to the product, $e$ I. The clockwork movement, an ordinary timepiece, periodically closes (once every five minutes in the case considered) the circuit of a special derivation constituted by two solenoids. The effect of the first of these solenoids is to bring back the fine wire bobbin to zero, and that of the second, which is arranged horizontally, is to render momentarily interdependent the axis of the bobbin and that of a revolution counter which, in every operation, revolves by an angle equal to that made by the movable bobbin before being brought back to zero. The rotations thus given periodically to the revolution counter are totalized, and may be read upon a horizontal dial actuated by an endless screw mounted upon the first axis of the revolution counter.

The movable bobbin, in moving over a vertical dial placed beneath the clock, makes known the power, $e$ I, furnished every instant by the apparatus controlled by the counter. The intervals of time that separate two different gatherings may be read upon the dial of the clock, and the integrations made by the apparatus may be known from the horizontal dial, so that the consumer has under his eyes at every instant all the elements of verification that are necessary to him.

*Clerc's Watts-Hour-Meter.*—This apparatus in principle is analogous to Blondlot's, but differs from it in the mode of periodical integration. The clock is kept in motion by a derivation from the line. It carries along, at a uniform angular speed, a crank fixed upon the principal axis. When the power expended is null, the needle fixed upon the axis of the movable bobbin is in the position represented in Fig. 3.

If a current passes into the two bobbins, the needle is deflected toward the right by an angle that counterpoises properly arranged upon the axis permit of rendering sensibly proportional to the product, $e$ I. The crank carries the needle back to zero once per revolution.

These rotations are transmitted to the revolution counter and totalized by means of a mechanical arrangement that may be seen in front in Fig. 3. This arrangement consists essentially of a small finger suspended from a lever fixed to the axis of the movable bobbin. When the lever moves from right to left, it carries along the large wheel mounted upon the axis of the totalizer. In moving from left to right, the finger slides over the felly of the wheel, and the rotation effected in the preceding movement continues as in the Blondlot apparatus. The needle indicates the power in watts, and the counter the total of the watts-hour furnished to the consumer.

By properly modifying the circuits, the maximum power to be integrated may be varied at will, and the apparatus even be rendered capable of measuring the energy consumed in a circuit traversed by alternating currents.

*Thomson's Electric Meter.*—This counter is especially designed for the measurement of the energy furnished to circuits traversed by alternating currents. The principle and arrangement of it are absolutely new.

The lower part of the apparatus contains a small transformer whose primary circuit is traversed by the total current to be integrated. The secondary circuit of this transformer is alternately and automatically closed upon two strips of platinum bent into the form of stars and inclosed in two glass globes hermetically closed and connected by a horizontal glass tube containing glycerine. As the current produced in the secondary circuit is sensibly proportional to the primary circuit, the quantity of heat disengaged per unit of time in the platinum strips is proportional to the square of this primary circuit. This heat, being developed in one of the globes at a time, expands the air that it contains, forces the glycerine into the opposite globe, and, at a given moment, forces the whole to tilt. The current then traverses the second globe, and passes no longer into the first, which becomes cool while the second is becoming hot, until another tilting occurs, and so on.

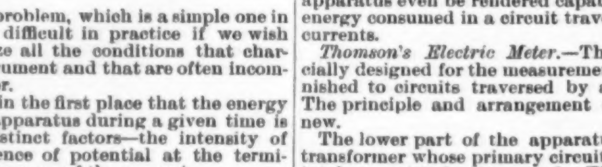


FIG. 3.—CLERC'S WATTS-HOUR-METER.

Upon properly proportioning the transformer and on arranging a connecting circuit, the description of which would take up too much time, it is possible to make the number of tiltings per unit of time proportional to the efficacious intensity of the current. A revolution counter that integrates the number of tiltings will therefore make known the quantity of efficient electricity furnished to the circuit during the same time.

Although this apparatus is more especially designed for the measurement of alternating currents, it would be easy to modify it in view of its application to continuous currents.

*The Paccaud-Borel Meter.*—The characteristic of this apparatus is that, having been constructed for the measurement of alternating currents, it will not operate at all with continuous ones. It belongs to the class of motor counters, and is based upon the special properties of the magnetic field produced by alternating currents of great frequency. Let us imagine two bobbins whose axes are arranged rectilinearly, having an unequal number of spirals, and mounted in derivation, one with respect to the other, so that the total current traverses them at the same time and divides itself unequally at every instant in each of them in consequence of irregularity of the coefficients of self-induction. Each of these bobbins will tend to produce a magnetic field whose intensity will depend at every instant upon the intensity of the current traversing it. The resulting field will be rotary in a direction determined by the attachment of the terminals between themselves. A thin iron disk placed in the rotary field will tend to turn in the direction of rotation of the field, and so much the more quickly in proportion as the field and the current producing it is intenser. Upon arranging vanes, forming a regulator upon the same axis with the disk, and upon properly proportioning the different parts of the apparatus, it is possible, as may be seen, to form a sort of electric motor, which, between certain limits, will revolve with an angular speed sensibly proportional to the efficacious intensity of the total current.

It is with a view to obtaining such necessary proportions as perfectly as possible that the practical apparatus does not entirely resemble the theoretical one that we have just described.

In the model represented in Fig. 4, one of the magnetic fields is produced by an electro-magnet; on another hand the vanes of the brake are movable, and they rise in order to preserve the proportionality at great distances in reducing the value of the resistant couple due to the air. The number of revolutions registered upon a counter is proportional to the quantity of efficient electricity furnished to the circuit.

From the succinct description just given of some of the recent types of meters, it will be seen how many different principles there are to which recourse can be had for solving the important problem imposed by the distribution of electric energy. Before pronouncing upon their respective merits, it will be necessary to await the sanction of experience, and, for the two first, the results of the competition opened by the city of Paris.—*La Nature.*

## ON M. H. HERTZ'S EXPERIMENTS.*

DR. HERTZ, professor at Carlsruhe, published in the course of the year 1888-89 some experiments of great interest. I have repeated the greater number of them, with the assistance of M. De Nerville, at the Central Laboratory of Electricity in the Place Saint Charles. The large hall at the laboratory, which forms a rectangle of 15 by 14 meters, enabled me to reproduce them under very favorable conditions. The great interest of M. Hertz's experiments lies in the accurate information that we gain from them concerning the intervention of the external medium in electrical phenomena. The idea of this intervention is not new. After Faraday's experiments and Maxwell's theories, there remained no doubts upon this point in the minds of physicists; but the experimental proof was wanting, and this proof has now been given to us by M. Hertz's experiments. They show in particular that the medium which intervenes in electrical phenomena is the same ether that forms the seat of luminous phenomena; that the disturbances in both kinds are set up under the same condition, and with the same rapidity; and, lastly, that there is identity of nature between certain electrical phenomena and the luminous phenomena.

What is an electrical current? We do not know; but the following hypothesis gives us a very good idea of what occurs. Let us consider a conducting wire, in its natural condition, as connected to indefinite elastic cords, normal at its surface. To introduce a current into the wire is to displace the wire in a direction parallel to itself and with the nature of the current, so as to draw with it the points of attachment of all the cords. These latter become oblique and remain oblique while the current is passing, but return to their original position and resume their normal direction as soon as it ceases. These cords being indefinite, the effect of the current makes itself felt at any distance, but evidently less and less in proportion as the distance is increased. But it is also very evident that the effect is not felt everywhere at the same moment; it arrives progressively at the various points, and takes rather more than eight minutes to arrive at the sun. We may add that what is called the *coefficient of self-induction* is only the coefficient of the term that corresponds to this external work of the creation of the field.

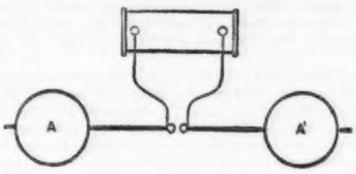



FIG. 1.

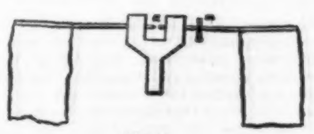


FIG. 2.

It should be well understood that the phenomenon of which I have just spoken has not its analogy in luminous phenomena. In order to produce the resemblance, we must consider alternating currents. Let us introduce into our rectilineal conductor an alternating current of a sinusoidal form; the elastic cords will be drawn alternately into first one direction and then the other, and each one will be the seat of transverse vibrations propagated along its length. We will, according to custom, call length of undulation the path taken by the movement during a complete vibration backward and forward.

It is under the action of these movements, transmitted through ether, that a conducting wire stretched parallel to the first becomes the seat of induction currents. We may remark that if this wire is stretched at a distance from the first equal to the length of undulation, it will give, at about the same intensity, the same phenomenon of induction as if it were in contact; but that if it were placed at half this distance, *i. e.*, at a distance equal to a half length of undulation, the induced movements would be at each moment of a nature contrary to those produced in a wire adjoining the conducting wire, the only ones that we are accustomed to consider, and that the elementary laws of direct and inverse currents would be reversed.

The experimental verification of this fact would be the most direct proof of the propagation of the electric action; but if the rate of propagation is the same as that of light, viz., 300,000 kilometers per second, and if the period of our alternating current be $\frac{1}{100}$ of a second, the wave length will be 3,000 kilometers, and the distances of the two pipes would be 1,500 kilometers.

In order to get a wave length of three meters, the duration of the vibration must not exceed $\frac{1}{100000000}$ of a second.

We cannot hope to produce directly alternating currents of such a short period; but we know that under certain conditions of resistance of the current the discharge of the Leyden jar is effected by isochronous vibrations of very short duration; but these oscillations have always been found to range from $\frac{1}{10000}$ to $\frac{1}{100000}$ of a second. It is the same with the oscillation produced in the open circuit of the secondary wire of a Ruhmkorff coil at each interruption of the inducting current. This minimum duration of $\frac{1}{100000}$ of a second corresponds to a wave length of three kilometers.

One of Mr. Hertz's great achievements is to have found a method by which still more rapid oscillations can be given, the duration of which may be reckoned in billionths of a second. Theory points out that if two spheres (Fig. 1) charged with different potentials are put in communication by a conductor, equilibrium is established by a series of isochronous oscillations, rapidly checked, like those of a liquid contained in communicating tubes, the level of which has been disturbed. The duration of the oscillation depends on the capacity, C, and the coefficient of self-induction, L, of the system, and is given, when the resistance of the joining wire may be disregarded, by the formula—

$$T = 2\pi\sqrt{LC}$$

Such is, briefly, Mr. Hertz's apparatus, which we will call the exciter; it consists essentially of a rectilineal conductor cut in the middle and terminated at its extremities by two capacities, two large spheres, or two plates.

In the apparatus placed before the society the rectilineal conductor has a diameter of 0·5 centimeter and a length of 40 centimeters; the two spheres are 30 centimeters in diameter. Consequently, we get—

$$C = \frac{15}{9 \cdot 10^{11}}$$

$$L = 400$$

$$T = 16 \cdot 10^{-9}$$

From this we deduce for the length of undulation, the speed being supposed to be that of light,

$$\lambda = 4{\cdot}80 \text{ meters.}$$

In order to realize the instantaneous charging of the exciter, we leave an interruption in the middle, terminating the two opposite extremities by little balls and putting each of these balls into permanent communication with the two poles of a Ruhmkorff coil. The bobbin employed with the exciter in question is a Carpentier bobbin (type 600 fr.) working with a Marcel-Deprez interrupter and a current which is 15 amperes when the interruption is suppressed.

This is the action of the apparatus: At the moment when induction is produced on the secondary wire of the coil, the two branches of the exciter which form the extremities are brought to different potentials and at the same instant a bright spark flashes between the two balls, establishing during a very short period between these two balls a passage of low resistance, across which the rectilineal conductor discharges upon itself independently, almost as if it were separated from the bobbin. These oscillations are stopped before the following oscillation of the bobbin, which does not return until after $\frac{1}{10000}$ second has had time to take place, and they are renewed in the same manner at each oscillation of the bobbin. The condition of the exciter may be compared to that of a violin string, the vibrations of which are kept up by the sharp drawing of the bow. The essential condition of the phenomenon is, therefore, that the spark should pass and should be of the intensity required. If we separate the balls so as to suppress it and to leave open the secondary wire of the bobbin, we no longer get the proper oscillations of the bobbin, which are about 10,000 times slower than the proper oscillations of the exciter.

The production of rapid oscillations depends on complex and even somewhat mysterious conditions; they are influenced not only by the distance of the two balls, but also by the condition of the surface, the degree of polish of these balls, the dimensions of the bobbin, the intensity of the inducing current, etc.; a pretty strong violet light falling upon the balls completely puts a stop to the oscillations. We know whether the apparatus is working well by the report and aspect of the spark; this spark is formed of very fine and very bright rectilinear strokes giving rise to sharp crepitations. The exciter naturally develops in the neighboring conductors alternating induced currents. I established experimentally, in 1880 (Comptes rendus de l'Academie des Sciences, vol. xci, pp. 408 and 493, 1880), the laws of alternating currents. I showed, in particular, that the circuit seemed to have, instead of its resistance, R (the *true resistance*), an *apparent resistance* equal to

$$\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}$$

In actual experiments, in consequence of the excessive smallness of T, the second term of the radical takes an enormous value, before which the proper resistance of the conductor may absolutely be disregarded, and thence arise several necessary consequences which impart to the phenomenon quite a special character.

In the first place, the resistance of the conductor is of no importance; all else being equal, the phenomena produced in a wire will be independent of the nature and thickness of the wire. In the second place, there will be established between two neighboring points of the same conductor, which are separated by an apparent resistance which may be enormous, differences of potential out of all proportion to those that we generally observe. Lastly, that property of variable currents of penetrating only progressively the thick

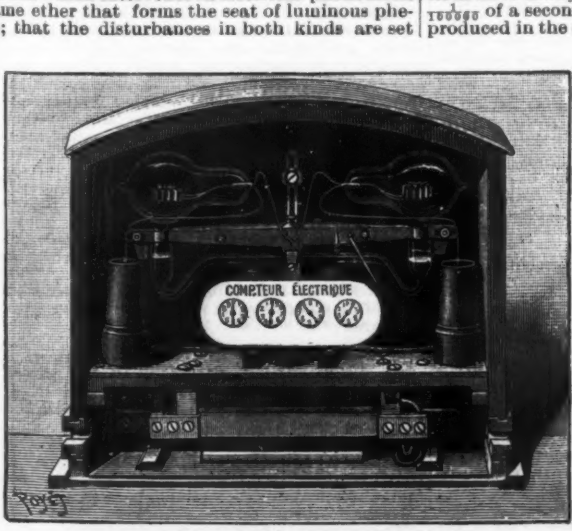



FIG. 2.—THOMSON'S ELECTRIC METER.

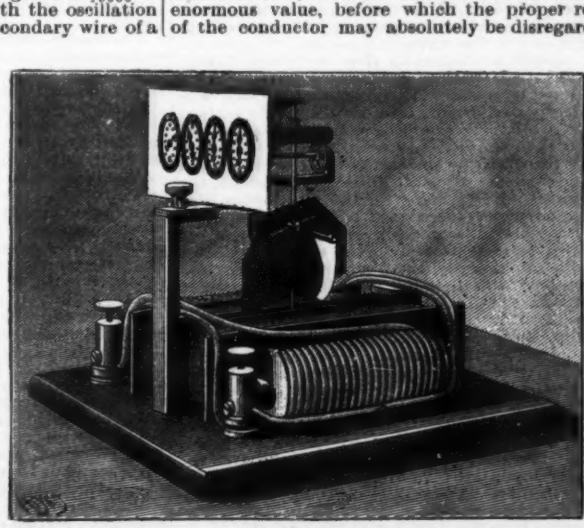


FIG. 4.—PACCAUD-BOREL ELECTRIC METER.

* By M. Joubert, in *Bulletin de la Societe Internationale des Electriciens*, July, 1889. For a translation of a paper by Dr. Hertz on this subject see SCIENTIFIC AMERICAN SUPPLEMENT, No. 720.

layers of the conductor will be carried to its extreme, and the electrical movements will be solely superficial.

In fact, when the apparatus is working well, as at present, and the oscillations are produced, there is not in the room or in the adjoining apartments any piece of metal, large or small, insulated or in communication with the earth, from which we cannot draw sparks. We see them flash between the two extremities of a wire which we curve into a bow, between two pieces of money or two keys that we bring together; we obtain them, by presenting the point of a knife, from the gas pipes, water pipes, etc.

In order to analyze this phenomenon, Mr. Hertz uses a wire bent into a ring, the extremities of which can be brought together at will. We observe the sparks which pass between the extremities of the wire, and we judge of the intensity of the phenomenon by the explosive distance and by the brilliancy of the spark. On trying rings with different diameters, we find one with which the sparks take their maximum length; it is then that the period of the electrical movement excited in the wire which constitutes the ring is the same as that of the exciter; the ring acts as resonator. And, in fact, if we take a frame of the same diameter, but in which the wire makes several turns, we obtain much feebler sparks.

With a resonator well in accord, the sparks are from 8 to 10 millimeters in the neighborhood of the exciter; they decrease rapidly when the distance increases, but they are still visible at 15 or 20 meters from the apparatus.

I hoped to render these phenomena visible to an audience by employing a frog, but the frog gives absolutely nothing.

Instead of M. Hertz's ring, M. De Nerville and I have employed a rectilinear resonator composed of rods, formed of two copper wires, placed end to end, the extremities of which bear capacities consisting of sheets of tin (Fig. 2).

We determine by trial the length of the wires and size of the sheets of tin most suited to our purpose.

At the interruption, *a*, one of the wires is rounded, and the other cut to a point. The system constitutes a species of micrometer; one of the wires bears a screw thread, and the explosive distance is made to vary by turning the milled head, *m*.

The spark flashes in the space between the two wires. When the exciter is working in the large hall of the laboratory, and the length of the wires and the size of the capacities are well regulated, we observe very brilliant sparks, which attain to seven or eight millimeters in the neighborhood of the exciter, and which are visible in all the other halls, in the yard, in the street, and even at a distance of more than fifty meters and through several walls.

This apparatus leads us to a very curious experiment, showing plainly the influence of light on the production of the oscillations. On bringing the resonator near to the exciter, we see that the character of the spark of the exciter changes, and at the same time the spark of the resonator disappears. On interposing any screen whatever, the phenomenon reappears in all its brilliancy. A sheet of glass has the same effect as an opaque screen; but, on the contrary, the interposition of a thin sheet of quartz, which allows a violet light to pass through, does not re-establish the phenomenon. The spark of the rectilinear resonator is at its maximum when the resonator is parallel to the exciter. The spark is *nil* when the resonator is in the symmetrical plane of the exciter, but when turned a few degrees, we see the spark reappear.

A stone wall acts in the same way as a transparent plate as regards the undulations, and we can hardly note any difference between the sparks obtained on the different sides of the wall. A metallic plate acts like a glass very slightly silvered; it reflects part of the wave, but lets a very considerable part pass through; thus the sparks are still very appreciable behind a metallic surface formed of a sheet of tin or a plate of zinc of 0·5 millimeter, or even of a plate of iron of 3 millimeters. These figures are simply the thicknesses of the plates tried, and they have no other meaning. It is probable that we should obtain a more complete reflection with plates of a greater thickness or greater conductivity.

I come now to one of M. Hertz's fundamental experiments, that which demonstrates in an undeniable manner the existence of the waves in question. It is an experiment exactly analogous to that by which Savart showed the interference of direct sound waves with waves reflected by a wall. The bottom of the hall was covered with plates of zinc, forming a metallic surface of 4 meters by 6 meters, and the exciter was placed opposite to it at the other extremity. The vibratory movements provoked by the exciter are reflected upon the metallic surface. By well known mechanism, the reflected waves, interfering with the direct ones, give rise to stationary waves separated by fixed nodes. And, in fact, if we place the resonator very near the wall, we only see faint sparks; they increase when it is drawn away, attain a maximum, then go on decreasing, and finally disappear at a distance of about 2·4 meters, to reappear again. Thus, there is a first node in contact with the wall, as in the case with sound waves when the reflection takes place with change of sign, and a second at a distance of 2·4 meters. The distance corresponds to half a wave length. If we take in the duration of the vibration as calculated above, *i. e.*, 16 billionths of a second, we deduce from it that the rate of propagation is 300,000 kilometers, *i. e.*, that of light.

Thus the vibratory electrical movements, and the vibratory luminous movements, are propagated with the same rapidity. They answer, then, to a modification of the same nature of the same medium. The only difference is in the duration of the period.

We can easily obtain electrical vibrations of a billionth of a second, and consequently wave lengths of 30 centimeters. The length of undulation of the visible rays is on an average 0·00005 centimeter; that is, 600,000 times shorter. M. Hertz carried still further the analogy between the two phenomena, and we have repeated the greater number of his experiments. Unfortunately they are too delicate to be shown in public, and I can only invite the members of the society to come and see them at the laboratory in the Place Saint Charles. I will now merely indicate the principal of them. An exciter with a very short period is placed according to the focal line of a parabolic cylinder having a height of 2 meters, with an opening of 1·20 meters.

The area in which the phenomenon is appreciable, and in which sparks can be obtained with the resonator, is limited by two vertical planes passing through the edges of the mirrors and parallel to the axis of the parabola of the base. We get thus a true parallel electric ray, similar to the luminous ray that would be given by a source of light placed in the position of the exciter. By receiving this ray upon a second mirror, similar to the first, we may repeat the well-known experiment of the two conjugate mirrors, and show that the vibratory movement is concentrated upon the focal line of the second mirror. We may also reflect this ray upon a plane, and show that the angle of incidence is equal to the angle of reflection. We may also make it pass through a prism, show that it deviates toward the base of the prism, and from the deviation deduce the index of refraction of the substance for the electric ray. M. Hertz made this last experiment with a prism of asphalt. This is the only one that we have not been able to repeat, for want of a prism of sufficient dimensions.

The president warmly thanked M. Joubert, and congratulated him upon the charm which he had imparted by his communication upon a subject of the highest scientific interest. He adds that the members of the society ought to congratulate themselves on the fact that their laboratory has enabled these remarkable experiments to be realized.

## THE TEACHING OF SCIENCE.*

In a report presented to the Bath meeting the committee gave an account of the replies they had received to a letter addressed to the head masters of schools in which elementary chemistry is taught. In this letter the committee had asked for a report on the chemical teaching, and also for a statement as to the methods which had been found to render the teaching most effective as mental training.

In commenting on these replies the committee pointed out that the evidence which had been collected was conclusive in showing that much of the teaching of elementary chemistry is far from satisfactory, and needs to be considerably modified if it is to effect that valuable mental discipline which science teaching can afford.

The committee are convinced that the high educational value of instruction in physical science has never been exhibited to its full advantage in most of our educational institutions.

Nevertheless, there exists already a considerable body of experience which proves that there is no more effective and attractive method of training the logical faculties than that which is afforded by a properly arranged course of instruction in physical science; by no other means are the powers of accurately ascertaining facts, and of drawing correct inferences from them, so surely developed as they are by the study of this subject.

Since the last meeting the committee have been actively engaged in discussing the lines which a course of elementary instruction in chemistry should follow. The committee were the more inclined to offer suggestions of their own, since they had learnt from the replies made to their letter of last year, by teachers in many of our well-known schools, that not only is the necessity for the adoption of improved methods fully recognized, but that teachers are anxious to receive advice and assistance in introducing them.

It cannot be too strongly insisted that elementary physical science should be taught from the first as a branch of mental education, and not mainly as useful knowledge. It is a subject which, when taught with this object in view, is capable of developing mental qualities that are not aroused, and indeed are frequently deadened, by the exclusive study of languages, history, and mathematics.

In order that the study of physical science may effect this mental education, it is necessary that it should be employed to illustrate the scientific method of investigating nature, by means of observation, experiment, and reasoning with the aid of hypothesis; the learners should be put in the attitude of discoverers, and should themselves be made to perform many of the experiments.

The lessons ought to have reference to subjects which can be readily understood by children, and illustrations should be selected from objects and operations that are familiar to them in every-day life.

Chemistry is particularly well adapted for affording this kind of instruction, and the committee are of opinion that a course which is mainly chemical will be most useful in developing logical habits of thought.

Chemical inquiry involves, however, the use of various physical processes, and these are themselves of great value from the point of view from which the instruction is being given. It is also of great importance that the learners should become acquainted with the characteristic instrument of physical science, viz., measurement, and, therefore, quantitative processes should be largely made use of.

Having agreed as to the general principles on which a scheme of elementary instruction in chemistry should depend, the committee gladly accepted the offer of Prof. Armstrong to draw up an account of such a scheme in sufficient detail to serve as a guide to those who have to provide such teaching.

Without pledging themselves to accept all its details, the committee consider that the scheme which Prof. Armstrong has prepared is in general accordance with their views as to what should constitute a course of elementary instruction in physical science.

With regard to the manner in which the scheme should be carried out, the committee wish to lay stress on the following points. In order that the plan shall produce its full educational effect, the instruction should be commenced at an early age, and be extended to every child in the school.

They do not desire to bring forward physical science as a substitute for any of the other principal subjects of study, but they ask that like these subjects it should be looked upon everywhere as a necessary part of education, and that it should receive a due share of the time devoted to school work.

It is well known that at present science teaching does not generally receive as much time and attention as is given to other studies. This was made clear in the report of the committee last year. It will be necessary to allot more time to the subject, and to employ a greater number of teachers.

A teacher should not be required to give practical instruction to more than from fifteen to twenty pupils at one time, although the classes at lectures and demonstrations might be somewhat larger.

While the scheme now proposed may involve the employment of a larger number of teachers of natural science, on the other hand fittings and apparatus of the simplest description are all that will be absolutely needed, and the cost of maintenance will be relatively small.

The committee are aware that the course of instruction now suggested is not in conformity with the present requirements of examining bodies. Its general adoption must therefore depend on their co-operation.

### SUGGESTIONS FOR A COURSE OF ELEMENTARY INSTRUCTION IN PHYSICAL SCIENCE, DRAWN UP BY PROF. ARMSTRONG.

Although the committee is ostensibly charged to report as to methods of teaching *chemistry*, chemistry pure and simple is not what is required in schools generally, and therefore the committee must be prepared to take into consideration and make recommendations as to a course of instruction preliminary to the natural science course proper, which in their opinion affords the most suitable and efficient preparation for later natural science studies.

After the most careful consideration of the question during at least ten years past, and after long holding the opinion that chemistry as usually understood is not the most suitable science subject for school purposes, I am now of opinion that a course which is mainly chemical is not only the best but also the only one possible, if we are to secure all the objects aimed at in introducing science teaching into schools.

Those objects are essentially: to train boys and girls to use their brains; to train their intelligence; to make them observing and reasoning beings, accurate observers, and accurate thinkers; to teach them to experiment, and that, too, always with an object—more frequently than not with what may be termed a logical object—not for mere descriptive purposes; to gradually inculcate the power of "doing," on which Charles Kingsley has laid so much stress, and which undoubtedly is the main factor of success in life.

It can scarcely be gainsaid that through chemistry more than through any other branch of natural science it is possible to give precisely that kind of "practical" training so requisite at the present day, because the student is able to ascertain *by experiment* what are the exact facts, and thus to arrive independently at an explanation, whereas in the case of other sciences more often than not the explanation of necessity has to be given by the teacher.

Chemistry as usually taught loses greatly in educational value because pupils are told, more often than not, that "so and so is the case," instead of being taught *how it has been found out* that such is the case; indeed, that which has to be proved is usually taken for granted.

Practical chemistry has hitherto, as a rule, been interpreted to mean the preparation of a few gases, etc., and the analysis of simple salts. Much useful information may be and is occasionally imparted during the performance of exercises of this kind, but the tendency undoubtedly is for analysis to degenerate into a mechanical drill, and, looking at the question from the practical point of view, and considering what is the general outcome of such teaching, probably we are bound to agree that the results thus far obtained are usually unsatisfactory.

The difficulty, however, is to devise a course sufficiently simple both in conception and when carried into practice, the cost of which is not too great; but with respect to this item of cost the committee has to make clear to parents and teachers the claim of natural science to a fair and proportionate share of the total expenditure, which certainly has never yet been granted to it.

By the introduction of such studies into the school course, a set of faculties are trained which it is all-important to develop, but which hitherto have been allowed to remain dormant, if not to atropy, through neglect, and which, it is admitted by all competent authorities, cannot possibly be developed by any amount of attention paid to literary and mathematical studies.

It is often not sufficiently clearly stated or understood that the advocates of natural science studies have no desire to displace any of the traditional subjects from the school course, and that all they ask for is a fair share of the child's time, attention, and brains—a share proportionate to the effect which such studies can demonstrably produce in developing the mental faculties of the individual; that, in fact, natural science claims to co-operate and in no sense puts in an appearance as a rival.

### STAGE I.—LESSONS ON COMMON AND FAMILIAR OBJECTS.

This first stage of instruction must be one of simple object lessons, but these should have an intimate relation to the child's surroundings, and should be made the pegs on which to hang many a tale. Probably the most satisfactory and practical mode of commencing is to get children to draw up lists of familiar and common objects under various heads, such as—

Natural objects.

Things used in building construction.

Things from which household furniture is made or which are in daily use.

Things used as clothing.

Food materials.

The children should be induced to describe these from observation as far as possible; to classify them according to their origin into mineral and animal and vegetable or organic; and occasion should be taken at this stage to give by means of reading lessons and demonstrations as much information as possible about the different things, their origin, how made, and their uses.

It is obvious in this way a great deal of geography and natural history (*Naturkunde*) might be taught in an attractive manner.

* Report of the committee, consisting of Prof. H. E. Armstrong, Prof. W. R. Dunstan (secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the present methods of teaching chemistry.—*Nature*.

Geikie's "Science Primer on Physical Geography" is the type of book which may be worked through with great advantage at this stage.

STAGE II.—LESSONS IN MEASUREMENT.

This stage should be entered upon as soon as children have learnt the simple rules of arithmetic, and are able to add, subtract, multiply, and divide, and to use decimals.

Lineal measurements may be first made, using both an English foot rule with the inch subdivided in various ways, and a metric rule, subdivided into millimeters. In this way the relation of the two scales is soon insensibly learnt.

Measurements of rectangular figures and the calculation of their areas may then be made.

After this the use of the balance may be taught, and the relation between the English and French systems may be learnt by weighing the same objects with the two kinds of weights. Use may then be made of the balance in determining the areas of irregular figures by cutting out rectangular and irregular figures from the same cardboard or thin sheet metal, and weighing these, etc.

Solid figures are next studied: a number of cubes made from the same wood having been measured, their volumes are then calculated, and the results thus obtained are compared with those which are obtained on weighing the cubes.

The dimensions and weights of cubes made from different woods or other materials are then ascertained, and thus it is observed that different materials differ in *density*. The study of the *relative density* of things generally is then entered upon. The ordinary method is easily learnt and used by children, a suitable bottle being provided by filing a nick down the stopper of a common two ounce narrow-mouth bottle; it may then be shown that the same results are obtained by the hydrostatic method of weighing in air and water, and it is not difficult to lead children to understand this latter method after they have determined the heights of balancing columns of liquids, such as turpentine, water, and saturated brine, of which they have previously ascertained the relative density. These hydrostatic experiments are of value at a later stage in considering the effects of atmospheric pressure.

By determining the dimensions of a cube and the weight of the water which it will displace, an opportunity is afforded to point out that if the results are expressed in cubic centimeters and grammes respectively, there is a practical agreement between the numbers, and hence, to explain the origin of the metric system of weights and the relationship between its measures and weights; the irrationality of the English system may then be explained.

The relative densities of a large number of common substances having been ascertained, the results may be tabulated and then the value of the data as criteria may be insisted on; as an illustration of their value, quartz, flint, sand, and gravel pebbles may be selected.

The children having determined their relative densities, the agreement between the results may be pointed out and the identity of the material explained. By drawing perpendiculars corresponding in height to the densities of various substances, a graphic representation is obtained which serves to bring out the value of the graphic method of representation.

A very valuable exercise to introduce at this stage is based on the well-known fact that in certain conditions of the atmosphere things appear moist; a muslin bag full of seaweed may be hung up under cover but freely exposed, and may then be weighed daily at a given time; simultaneously the state of the weather, direction of the wind, the height of the barometer, and the wet and dry bulb thermometer may be noted; on tabulating the results, and especially if the graphic method be employed, the variations in their relationship will be noticeable.

The thermometer, having thus become a familiar instrument, may be used to examine melting ice and boiling water; the construction of both the Centigrade and Fahrenheit thermometer may then be explained, and the effect of heat on bodies made clear. The density of ice and of water at various temperatures may then be determined, a Sprengel tube—which is easily made—being used for warm water; the bursting of pipes in winter, the formation of ice on the surface of water, etc., may then be explained. Afterward simple determinations of the heat capacity of a few metals, etc., and of the latent heat of water and steam, may be made in accordance with the directions given in a book such as Worthington's "Practical Physics."

STAGE III.—STUDIES OF THE EFFECT OF HEAT ON THINGS GENERALLY—OF THEIR BEHAVIOR WHEN BURNT.

As it is a matter of common observation that heat alters most things, the effects of heat on things generally should be studied; in the first instance qualitatively, but subsequently, and as early as possible, quantitatively. Bits of the common metals may be heated in the bowl of an ordinary clay pipe plunged into a clear place in an ordinary fire, or in such a pipe or a small iron spoon over a gas flame. The difference in fusibility is at once apparent, and in the case of metals like iron and copper it is noticeable that, although fusion does not take place, a superficial change is produced; the gradual formation of a skin on the surface of fused lead and tin is also easily perceived. Observations like this become of great importance at a later stage, and indeed serve to suggest further experiments; this is a point of special importance, and from the beginning of this stage great attention should be paid to inculcating habits of correct observation; the effect should first be recorded by the pupil, the notes should then be discussed and their incompleteness pointed out, and they should afterward be rewritten. The fusibility of substances which are not affected when heated in the tobacco pipe may be tested by heating them with a Fletcher gas blow-pipe on charcoal, and by heating little bits of wire or foil in such a flame it is easy for children to discover the changes which metals undergo when burnt, especially in cases such as that of zinc or copper or iron.

The further study of the effects of heat should be quantitative, and may well commence with water. It being observed that water disappears on heating, water may be put into a clock glass or glass dish placed on a water bath (small saucepan); it evaporates, and it is then observed that something is left. A known quantity of water by weight or volume is therefore evaporated and the residue weighed. This leads to the discovery that water contains something in solution. The question then naturally arises, What about the water that escapes? So the steam is condensed and the distilled water evaporated. The conception of pure water is thus acquired. An experiment or two on dissolution—using salt and sugar—may then be introduced, a water oven or even an air oven (a small Fletcher oven) kept at a known temperature being used, and the residue dried until the weight is constant. Rain and sea water may next be examined; the results afford an opportunity of explaining the origin of rain and of accounting for the presence of such a large quantity of dissolved matter in sea water. Then the various common food materials may be systematically studied, commencing with milk; they should first be dried in the oven, then carbonized and the amount of char determined, then burnt and the percentage of ashes determined. A small platinum dish, 15 to 20 grammes in weight, is required for these experiments, and a gas muffle furnace is of the greatest use in burning the char and in oxidizing metals. In addition to the discipline afforded by such experiments, a large amount of valuable information is acquired, and the all-important fact is established that food materials generally are combustible substances. Afterward mineral substances are examined in a similar manner, such as sand, clay, chalk, sulphur, etc., and then metals, such as lead, copper, tin, and iron, may be studied; their increase in weight is in striking contrast to the inalterability of substances like sand and salt and the destruction of vegetable and animal substances. Chalk, from which lime is made by burning, is found to occupy a middle position, losing somewhat in weight when strongly heated. The exceptional behavior of coal among mineral substances, and of salt among food materials, is shown to be capable of explanation, inasmuch as coal is in reality a vegetable and salt a mineral substance; but sulphur remains an instance of exceptional behavior requiring explanation. It is not exceptional in being combustible, as metals like magnesium and zinc are combustible, but in affording no visible product. The smell of burning sulphur, however, serves to suggest that perhaps, after all, there is a something formed which is an invisible substance possessed of an odor, and then follows quite naturally the suggestion that perhaps in other cases where no visible or perceptible product is obtained—as on burning charcoal, for instance—there may nevertheless be a product. Whereas, therefore, in Stage I., the pupil will have learned to appreciate the existence of a great variety of substances, and will have gained the power of describing their outward appearance more or less fully; and in Stage II., having learned how to measure and weigh, will acquire the habit of determining by measurement certain properties of substances, and will thus be in a position to express in exact terms the kind of differences observed; in Stage III, the pupil will be led to see that profound changes take place on burning substances, and that these changes involve something more than the destruction of the things burnt. The foundation is thus laid for the study of change, *i. e.*, chemical studies proper.

STAGE IV.—THE PROBLEM STAGE.

Many of the changes observed in the course of the experiments made in Stage III. might be examined and their nature determined, but the best to take first is a very familiar case, that of the rusting of iron.

*Problem I.—To determine what happens when iron rusts.*—The pupil *must* be led in the first instance to realize that a problem is to be solved, and that the detective's method must be adopted and a clew sought for. It is a familiar observation that iron rusts, especially when wet; what happens to the iron, why does it rust, is the iron alone concerned in the change? No information can be gained by looking at it—perhaps the balance which has brought to light so much in Stage III. may be of service. So the iron is allowed to rust in such a manner that any change in weight can be observed. A few grammes of iron filings or borings are put on to a weighed saucer or clock glass along with a bit of stiff brass or copper wire to be used as a stirrer, the iron is weighed, then moistened and exposed under a paper cover to keep off dust, preferably in a warm place; it is kept moist and occasionally stirred. After a few days it is dried in the oven and then weighed. The weight is greater. *Something from somewhere has been added to the iron.* Thus the clew is gained. Where did this something come from? The fact that when a tumbler, for instance, is plunged mouth downward into water, the water does not enter, and that on gradually tilting the tumbler to one side something escapes—viz., air—at once affords demonstration of the presence of air in the space around us. The iron rusted in this air, but was kept moist, so it may have taken up the something from either the air or the water. To ascertain whether the air takes part in the rusting, some iron borings are tied up in a bit of muslin and the bag is hung from a wire stand placed in a jam pot full of water, and a so-called empty pickle bottle, which in reality is full of air, is inverted over the iron; in the course of a few hours, as the iron rusts, the water is observed to rise until it occupies about one-fifth of the jar (determined by measuring or weighing the water); the something added to the iron during rusting appears therefore to come from the air, and the all-important fact is thus discovered that the rusting is a change in which not the iron alone, but also the air, is concerned. The experiment is several times repeated, fresh iron being used with the same air and the same iron put in succession into fresh portions of air, but the same result is always obtained, whence it follows that whatever it is in the air which takes part in the rusting, the air as a whole is not active. The changes previously observed to take place when iron, copper, lead, zinc, etc., were heated in air are then recalled; as the metals were found to increase in weight, it would appear probable that in these cases of change also the air was concerned.

These results at once suggest the question, What is air? So much having been learned by studying the change which iron undergoes in rusting, other changes which happen in air therefore are next studied.

*Problem II.—To determine the nature of the changes which take place on burning substances in air.*—The use of phosphorus is introduced by reference to a match. Phosphorus is then burnt under a bell jar over water and the result noted; the disappearance of some of the air again shows that the air is concerned. The fact that phosphorus smokes when taken out of the water in which it is always kept suggests that some change is going on. So a stick of phosphorus is exposed in air as in the previous experiment with iron, soon one-fifth has disappeared, and the phosphorus then ceases to smoke. The *quantitative* similarity of the two results suggests that iron and phosphorus behave alike toward air, and *vice versa*, and serves to confirm the idea that some constituent of the air present only to the extent of about one-fifth is active. But nothing is to be taken for granted, so iron is exposed in the phosphorus air residue and phosphorus in the iron air residue; as no change occurs, there is no room left for doubt. Recalling the experiments in which various metals were burned in air, in order to determine whether in these cases the same constituent of the air was concerned in the change, air from which the active constituent had been removed by means of phosphorus is passed through a heated tube containing bits of the metals. No change is observed. So it is evident that as a rule, if not always, one and the same constituent of air is concerned. The experiments with iron and phosphorus, although they show that the air is concerned in the changes which are observed to take place, do not afford any information whether or no the water which is also present is concerned in the change. Phosphorus is therefore burnt in a "Florence" flask closed with a rubber stopper; on removing the stopper under water some water enters, and by measuring this and the amount of water which will fill the flask the same result is obtained as in the previous cases. To be certain whether in this case anything enters or escapes from the flask it is weighed before and after the phosphorus is burned. There is no change in weight. But does nothing escape? Yes, much heat; whence it follows that heat is not material—that, although some of the air disappears, it is merely because it has become affixed to or absorbed by something else. This has been proved in the case of the rusting iron and the burnt metals. To obtain indisputable evidence in the case of the phosphorus, this is burned in a current of air in a tube loosely filled with asbestos to retain the smoke; the weight is found to increase. The observation that the phosphorus ceases to burn after a time suggests the introduction of a burning taper into the residue left by iron, etc.; it is found to be extinguished. Then a candle and subsequently a gas flame may be burned in a bell jar full of air over water. Reversed combustion may then be demonstrated in order to fully illustrate the reciprocal character of the phenomena. Thus it is ascertained that all ordinary cases of combustion are changes in which the air, and not the air as a whole but a particular constituent, is concerned, and no doubt remains that the same constituent is always active, but active under different conditions; it is realized also that the production of heat is the consequence of the union of the substance burned with the active substance in air. The experiment of exposing phosphorus in air affords the opportunity of demonstrating the evolution of heat, even in a case where no visible combustion occurs, as the phosphorus is always observed to melt. At this stage careful note should be taken of the appearance of the different products of combustion, and of a change such as that which occurs when the product from phosphorus is exposed to the air.

*Problem III.—To separate the active from the inactive constituent of air.*—It now has become of importance to get this active constituent of the air by itself, and the question arises whether it cannot be separated from one of the metals or other substances with which it has been found to combine. The pupil is therefore told to collect information about the different substances formed by burning metals, etc., whether they can be obtained in sufficient quantity to work with, etc. Iron rust and iron scale are easily obtainable, and so is copper scale; zinc is burnt to produce zinc white, which is used as paint; lead is also burnt on a large scale, and in this case it appears that one or other of two substances is formed—litharge at a high temperature, red lead at a lower temperature. This peculiarity of lead suggests the study of the two products in the hope of discovering the clew to a method. Weighed quantities of the litharge and red lead are heated; it is observed that only the latter changes in appearance and that it loses weight. But what does it lose? It was formed by merely roasting lead in the air, and the something which it loses must therefore have been derived from the air. If the red lead is heated in a tube, a gas is given off which is collected and tested—how? With a taper or glowing splinter, as it is to be supposed that the gas will support combustion if, as is to be expected, it is the active constituent of air. The *discovery* of the active constituent of air is thus made! If air consist of this gas and that which remains after exposing phosphorus or iron in air, then by adding to such residual air as much of the gas from red lead as was withdrawn, air should be reobtained. This is found to be the case. The names of the two gases are now *for the first time* stated, and an easy method of preparing oxygen is demonstrated, such as that of heating chlorate, but without any explanation. The conclusion previously arrived at, that probably in all the cases previously studied of changes occurring in air, the oxygen is the active substance, may now be verified by burning or heating in oxygen the substances which had been burned in air.

So much having been learnt of the chemistry of air, the study of the pressure exercised by air may next be taken up, and the common pump, the force pump, the barometer, and air currents may be discussed and explained. Nowadays the charts given in the daily papers and the Ben Nevis and glycerine barometer readings quoted in the *Times* makes it particularly easy to explain the barometer. The pupil should be led to make barometer curves.

*Problem IV.—To determine the composition of chalk.*—The discovery of the *composition* of the air in the course of experiments made with the object of determining the nature of certain changes naturally suggests that the attempt be made to ascertain the composition of other things by studying the changes they undergo. Chalk is known to give lime when burnt, and experiments made in Stage III. have indicated that chalk loses something when burnt—the idea that an invisible something is given off is especially probable after the experiments with red lead have been made; so it is decided to heat chalk strongly, but before doing this chalk and lime are examined comparatively.

Chalk is not observed to be altered by water; on shaking it up with distilled water and evaporating some of the filtered liquid in a weighed dish, very little residue is obtained—so it is established that it is but very slightly soluble in water. Lime is slaked, weighed quantities of lime and water being used; the retention of a considerable amount of water, even after exposing the slaked lime in a drying oven, shows that the slaking involves a definite change in composition—that slaked lime is lime and water. The solubility of the lime is next determined, and found to be considerably greater than that of the chalk. It is found that chalk is but very slightly altered in weight when heated over a gas flame, and that it is only when it is strongly heated that it is converted into lime; so the chalk is strongly heated in an iron tube in a Fletcher blow-pipe furnace, when gas is freely given off. This is tested with a taper which it extinguishes, so it cannot be oxygen, but may be nitrogen; if it be nitrogen, when mixed with oxygen in the proportion of 1 to 4, it should give air, but this is found not to be the case; so evidently it is a peculiar gas, and may be called chalk gas. If chalk consist of this gas and lime, it should be possible to reproduce chalk from them; so the gas is passed through a small weighed tube containing lime, and the tube is found to get heavier. But lime and chalk are so much alike that it is difficult to say that chalk is formed; perhaps dissolved lime will act similarly; the gas is therefore passed into or shaken up with lime water. The precipitate which forms looks like chalk, and probably is, but this remains to be decided. The discovery of this behavior of chalk gas, however, is important as affording a means of again comparing the gas from chalk with nitrogen. In working with lime water it is scarcely possible to avoid noticing that a film forms on its surface; by exposing a quantity of the lime water a considerable amount of the precipitate is obtained; its resemblance to chalk is noted, and the possible presence of chalk gas in air is thus suggested; but in view of the absence of proof of the identity of the precipitates with chalk, a decision is reserved. The discovery is made, however, that air contains something besides oxygen and nitrogen.

It being thus established that chalk consists of two things, lime and chalk gas, at this stage it is pointed out how firmly these two constituents hold to each other in the chalk. The absorption of the gas by the lime—its entire disappearance, in fact—is commented on. Accurate determinations of the loss of weight on heating crystallized chalk (calc spar) should at this stage be carried out before the class, if not by the pupils, so that the numbers may be quoted and that it may become impressed on them that the proportion in which the lime and chalk gas are present is constant. Their attention is recalled to the oxides previously studied, it being pointed out that on inspection these afford no indication that they contain oxygen; that here again the gas entirely loses its individuality on entering into union or combining. That oxides contain their constituents in fixed proportions may be determined experimentally by oxidizing finely divided copper and determining the increase in weight, lime being used as drying agent. In this way the characteristics of *compounds* are elucidated. Then the comparison may be made with air, and the fact made clear that it behaves as a mere mixture. Still no reference should be made to elements.

*Problem V.—To determine what happens when organic substances are burnt.*—The experiments thus far made have shown that phosphorus and a number of metals burn in the air because they combine with the oxygen, forming oxides, heat being given out *as a consequence*; but that chalk when burnt is split up or decomposed into lime and chalk gas, this result being a consequence of the heating alone, the air having nothing to do with it. It remains to ascertain what happens when organic substances are burnt, as these give no visible product beyond a little ashes. As in all cases when vegetable or animal substances are burnt a certain amount of "char" is obtained, which then gradually burns away, charcoal or coke is first studied. It having been discovered that the oxygen in air is the active cause of burning in many cases, it appears probable that the air is concerned in the burning of charcoal, coal, etc.

As when once set fire to these continue to burn, the charcoal is at once heated in oxygen; it burns, but no visible product is formed; it therefore follows that if the charcoal is oxidized, the oxide must be an invisible gas. How is this to be tested for? What gases are already known to the pupil? How are these distinguished? Oxygen is excluded. Is it perhaps nitrogen, and is not perhaps the nitrogen in air, merely used-up oxygen as it were, produced by the burning of organic substances? Or is it perhaps that gas which was found in the air along with oxygen and nitrogen, and which turned lime water turbid? This last being an easy test to apply, is at once tried; the lime water is rendered turbid, and so to leave no doubt a sufficient amount of the gas is prepared and passed into lime water, the precipitate is collected, and the loss it suffers on heating is determined and found to agree with that suffered by the precipitate prepared from chalk gas.

Finally, to ascertain whether the product is really heavier than the charcoal burnt, as in the case of the metals previously studied, the charcoal is burnt in oxygen in a tube connected to a flask containing milk of lime with a lime-drying tube attached to it; the tube is weighed before and after burning. Thus the discovery is made that chalk gas is an oxide of carbon and that chalk consists of at least three things.

It may be objected that to make the experiment in this manner takes too much time; but to this it may be answered that such experiments are precisely of the kind of those made in actual practice, and that they exercise a most important influence in teaching the pupils to take nothing for granted, never to jump at conclusions, and to rest satisfied if they progress surely, however slow the advance may be.

A number of organic substances may now be burnt, and the gas passed into lime water; chalk gas is found in every case to be a product, and hence the presence of a common constituent—carbon—in all is established. In making these experiments the formation of a liquid product is observed, so it is evident that chalk gas is not the only product, or carbon their only constituent.

Food materials generally having been found to contain "carbon," as they are obviously in some way destroyed within the body, and it is known that air is necessary for life, the question arises, what becomes of food, and why is air necessary for life? Is the food, perhaps, in large part "burnt up" within the body, thus accounting for the fact that our bodies are always warm? The characteristic product of combustion of carbonaceous substances is therefore tested for by breathing into lime water. The discovery thus made affords an opportunity for a digression and for explaining how plants derive their carbon from the air.

*Problem VI.—To determine what happens when sulphur is burnt.*—From the results of the experiments with carbon, it appears probable that the disappearance of sulphur when burnt is also really due to its conversion into a gaseous oxide, so it is kindled and introduced into oxygen; if it be burnt over water in a bell jar in a spoon passing through the stopper (a rubber cork), the water is seen to rise; if, on the other hand, it be burnt in a dry flask closed by a rubber cork carrying a gauge tube, as suggested by Hofmann,* the volume is seen to be almost unchanged after combustion. It follows, therefore, that the sulphur and oxygen unite and form a soluble product. Sulphur is next burnt in a tube in a current of oxygen, and the gas is passed into water; a solution is thus obtained having the odor of the gas and sour (acid) to the taste.

The fact that carbon and sulphur—both non-metals—behave alike in yielding gaseous oxides suggests that a comparison be made of their oxides; so the acid solution is added to lime water; a precipitate is formed, which redissolves on adding more of the sulphur gas solution; on the other hand, on adding the lime water to the acid liquid, this latter after a time loses its characteristic smell. There can be no doubt, therefore, that the sulphur gas does in some way act upon the lime.

The experiment is then made of burning the sulphur in a weighed tube containing lime; the weight increases, so that no doubt remains that sulphur, like carbon, forms an oxide when burnt. The discovery that the addition of more of the sulphur oxide leads to the dissolution of the precipitate which it first forms in lime water suggests trying the effect of excess of the carbon oxide on the lime water precipitate; this is done, and the discovery is made that the precipitate gradually dissolves.

The solubility of the new substance may then be determined by passing the gas into water containing chalk in suspension, filtering, and evaporating. This leads to the observation that a precipitate is formed on heating the liquid, and this is soon found to be chalk. An opportunity is thus afforded of explaining the presence of so much "chalk" in water; of demonstrating its removal by boiling and by lime water; and the effect it has on soap.

The observation that the oxides of both carbon and sulphur combine with lime suggests trying whether the one will turn out the other; so the solution of the sulphur oxide is poured on to chalk; effervescence is observed, and on passing the gas into lime water a precipitate is obtained. The production of this effect by the *acid* solution suggests trying common vinegar—a well known *acid* substance.

This also is found to liberate chalk gas, and the discovery of an easy method of preparing chalk gas is thus made. The oxide formed on burning phosphorus, having previously been found to give an acid solution, is tried, and it is found that it also liberates chalk gas. As a good deal of vinegar is found to give very little chalk gas, the question arises, Are there not acids to be bought which will have the same effect and are stronger and cheaper? On inquiry it is found that sulphuric acid or oil of vitriol, muriatic acid or spirits of salts, and nitric acid or aquafortis may be bought, and that these all act on chalk.

The behavior of chalk with acids affords a means of testing the lime water precipitate obtained in working out Problems IV. and V. In this manner the pupil is led to realize that certain agents may very readily produce effects which are only with difficulty produced by heating—that the *chemical agent* may produce very powerful effects.

The ready expulsion of the carbon oxide of chalk suggests that other substances not yet studied, such as the metals, when treated with acids may behave in a special manner which will afford information as to their nature. At this point, prior to making the experiments with the acids, an explanation may be given of the names *oil of vitriol*, *spirits of salts*, and *aquafortis*; the processes by which they are made may be described and illustrated, without, however, any attempt being made to explain them from the chemical point of view. The sulphuric acid should be made from green vitriol, and its behavior on dilution should be demonstrated as well as its use as a drying agent.

(*To be continued*).

* By burning carbon also in this way a most effective demonstration is given of the fact that no loss or gain of matter attends the change, and that only heat escapes; the results in the case of carbon and sulphur are particularly striking, as the products are gaseous and invisible.

## THE GIANTS OF STARRY SPACE.

THE tendency of recent astronomical investigation and discovery is to render our conceptions of celestial space more and more definite. The stupendous void in which the sun with his planets and all the starry systems float is presented to the imagination in a comprehensible aspect when we are able to gauge its distances here and there, and to tell something of the actual magnitude as well as of the real constitution of the bodies that exist there. Within the solar system these facts have been ascertained with a great degree of accuracy. When we say that the measured distance of the sun may be in error 100,000 miles one way or the other, we seem to invalidate the idea of accuracy, but that idea is restored upon considering that 100,000 miles is less than one-eigth of the sun's own diameter and less than one nine-hundredth part of its distance from the earth. If, taking the City Hall in New York as a starting point, we should undertake to estimate the distance to St. Paul's Cathedral in London, and our calculations should prove to be in error in the same proportional extent as in the case of the sun, we should yet find that the other end of our imaginary measuring rod would lie within the limits of the English metropolis. The ascertainment of the distance separating our little earth from an orb so remote as the sun must be regarded as one of the most surprising achievements of human genius.

But when we come to the vast spaces that divide our sun and his little fleet of circling worlds from his fellow suns, the stars, the boldest imagination is appalled at the thought of applying, so to speak, a foot rule to the measurement of such distances. Yet the rule has been applied with results which, amazing as they appear, are yet entitled to confidence. This sounding of the star depths is distinctly an enterprise of our day. Herschel's so-called star gauging, while it threw light on the form of the visible universe, did not tell us how many miles it was from the earth to the stars. It may surprise many readers to know that even now there are only thirty or forty stars out of all the millions visible whose distance has even approximately been ascertained. The degree of accuracy in these measurements is, of course, nothing like so great as in the case of the sun. But observations are now going on which in a few years will vastly increase not only the number of stars whose distance has been tested, but also the accuracy of the results in the case of those stars that are not too tremendously remote to defy all attempts at measurement. In other words, astronomers are making more certain their hold upon those projecting capes and headlands that here and there bring the shores of the starry universe within the reach of their trigonometry. They are finding out where we are in the ocean of infinity.

It may be interesting to run over some of these measurements and see what they imply. Of course, when we know the distance of a body, we can tell something of its magnitude, and we shall find ourselves brought into the presence of solar monsters in comparison with which our sun is dwarfed into insignificance. Astronomers do not use miles in describing the distances of the stars, because with so small a unit the numbers involved are too large to be conveniently handled. Even the distance of the sun, ninety-three million miles, is too small to serve as a good unit of measurement in sounding the depths of space. The distance that light can travel in a year, which is 63,000 times the space separating the sun from the earth, or in round numbers 5,859,000,000,000 miles, is taken as the unit of measurement for star distances, and this yard stick for the stars is called a light year.

One of the most beautiful stars in the sky, and one that has been admired in every age of the world, is the star called Vega in the constellation of the Lyre. It is remarkable for the exceedingly delicate tint of blue in its light. This star may be seen almost directly overhead at midnight in the middle of the summer, and with its soft radiance it forms one of the most charming features of the celestial landscapes at that season. In the early winter evenings it flashes low in the northwest. But, when we look at Vega through the megascopic eyes of the parallax hunter, it changes from a delicately beautiful star to a most portentous cyclops of space. The distance of Vega, according to Dr. Elkin's measurement, is about ninety-seven light years, or more than six million times the distance of the sun. But the amount of light that reaches the earth from Vega is about one forty-thousand-millionth part of the amount that we get from the sun, and since we know that light varies inversely as the square of the distance, it is easily seen that Vega really pours forth more light than nine hundred suns like ours combined. Its heat is undoubtedly in the same proportion, so that if the earth should come as near to Vega as it is to the sun, we should wither into cinders before the fierce blue gush of its overpowering rays. If Vega is the center of a system of worlds, they must either revolve at enormous distances from it or else their inhabitants must possess the heat-defying powers of salamanders.

But we can go on to a still mightier orb than Vega. Let your eye run along the bending handle of the Great Dipper, and following the same curve beyond the last star in the handle, sweep across the sky until it is arrested by a bright golden-yellow star of the first magnitude. This is the famous Arcturus, celebrated among men since Job's time at least. The striking color of the star, its brilliancy, and its solitary situation as if withdrawn into a place apart from the general host of heaven, all combine to make it a cynosure of the northern sky. Arcturus has yielded a parallax within the past year that places it at the distance of no less than 180 light-years, or 11,400,000 times as far as the sun. It follows that Arcturus is equal in radiating power to more than 3,000 suns like ours. It is but fair to say that other estimates of the light received from the star make Arcturus equal to at least 6,000 suns! Yet Arcturus may be surrounded by planets too, but how shall we form a conception of the life forces, the physical powers, the unnumbered activities of organized existence in operation within the blazing precincts of such a solar system as that? Astronomy has long since accustomed us to think of the earth as an insignificant atom of creation, but in the presence of this Arcturian wonder our whole planetary system, with the glorious orb that lights and governs it, fades away before our exalted vision into a flicker of fireflies against the darkness.

Even the Pole star, that speck of light in moonless nights that sailors have steered their ships by, is a sun nearly a hundred times as luminous as ours. The marvelous "runaway star," that astronomers have discovered under the bowl of the Great Dipper, a star that is flying through space so fast that nobody can imagine how it got started or where it is going, although it is far too small to be visible to the naked eye, is yet thirty times as great an illuminator of space as the sun; and who shall say that it does not bear with it in its flight orbs that play as great a part in the scheme of creation and of life as that which Satan detected:

"——fast by, hanging in a golden chain,
This pendant world in bigness as a star
Of smallest magnitude, close by the moon."

If we wish to behold afar off a sun equal to ours, we must turn to the southern heavens, to the constellation of Ophiuchus, where, in a little fifth magnitude star that the eye would probably overlook but for the fact that several other faint twinklers grouped near it combine their feeble rays to catch the sight, we may look upon the peer of the blazing day god that rules our tract of space. Thus would he be diminished in glory if removed to a corresponding distance.

But there are suns and suns, and, after all, ours does not belong to the humblest rank in the solar peerage. The nearest star in the northern hemisphere, 61 Cygni, is so small, or so feeble in radiating power, that eight-

een similar orbs would have to combine their energies in order to equal our sun. And the parallax of another small star, 21,258 LI., has been measured, which indicates that that star possesses a luminosity equal to only one one hundred and thirteenth part of that of the sun. Still the evidence so far obtained all points to the conclusion that there is a far greater number of suns in the universe that are larger than ours than there is of those that are smaller. Indeed, it is probable that we shall find that even such a giant of radiant energy as Arcturus does not represent the very greatest order of the suns of the universe. Many are so far away that at present there appears to be no hope of measuring their distance, and among these there may be solar orbs a thousand times greater than the greatest yet discovered.

Still we should not entertain too humble an opinion of our surroundings because our lot has not been cast under the beams of some more princely star, for along with the evidence of the vast extent of the material universe and the enormous magnitude of its chief members has come the proof of its essential unity. Vega may blaze as brightly as a thousand suns, but is not its glowing atmosphere filled with that most familiar thing, hydrogen, which we drink with every drop of water? Does not the vapor of iron add to the splendor of its shining? The suns are all akin, and there must be unity even in the infinite.—*N. Y. Sun.*

## AGRICULTURE IN THE DESERT.

ONE of the curious outlets for French capital is that which has been formed by a company established a few years ago, having for its object the colonization of the Sahara desert by the creation of a series of oases or cultivable areas, which should, when developed, produce a profitable return, even if it failed to make the desert blossom as a rose.

The project has been a favorite one with French engineers for many years past, and the efforts which have culminated in the results obtained by the present company date from 1880, although still earlier pioneer work had been done by M. Jus and later by M. Dufforg, who actually established with considerable success a date palm farm in the desert about twenty-five years ago.

A more recent venture is due to the enterprise of the Marquis de Courcival and M. George Roland, a mining engineer who acquired some small oases and surrounding area of desert with the intention of seeing what could be done in the way of development and cultivation. The map (see Fig. 2) will give an idea of the district in which the property created by the company is situated. It occupies a central position in the Algerian Sahara, and is known as the region of Oued Rir', of which Tougourt is the capital place. One great advantage possessed by this situation is that it is close to a line of railway running through the desert to the south, and which was opened as far as Biskra a year ago. An extension of this line for military purposes is probable; and, after all, the distance from Paris is not so very great, since a traveler may easily arrive at Biskra three days after leaving the French capital.

The plan, Fig. 1, shows the area worked by the company to a larger scale. From this plan it will be seen

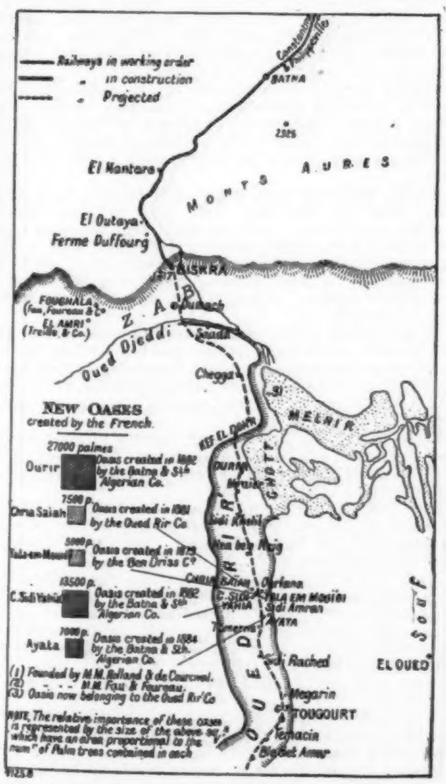



FIG. 3.—THE OUED RIR' AND ITS NEW OASES CREATED BY THE FRENCH.

that Oued Rir' is a valley running from north to south with a rocky plateau on each side, and forming a plain about fourteen miles in width. In this valley exist several small natural oases, which owe their existence to the presence of water, which is found a short distance below the surface.

Before the company took possession this water had been tapped by a considerable number of shallow wells, most of them of ancient date, made by the inhabitants of the desert, and a few more recent, which had been sunk by French soldiers or by temporary settlers. In the district the company own five distinct properties, the most important of which is Ou Rir, of about 1,800 acres, laid out in gardens and plantations, with buildings for workmen. The estate of Sidi-yahia, of about 600 acres, is developed in a similar manner, as also is the smaller property of Ayata. Ou Rir is about fifty miles south of Biskra, and forty feet below the sea level; it occupies the head of the district of Oued Rir', and lies over the well defined line of underground waters.

The plan, Fig. 3, shows the district of Oued Rir' to a larger scale, with the locations of the oases that have been created by the company, together with their relative importance.

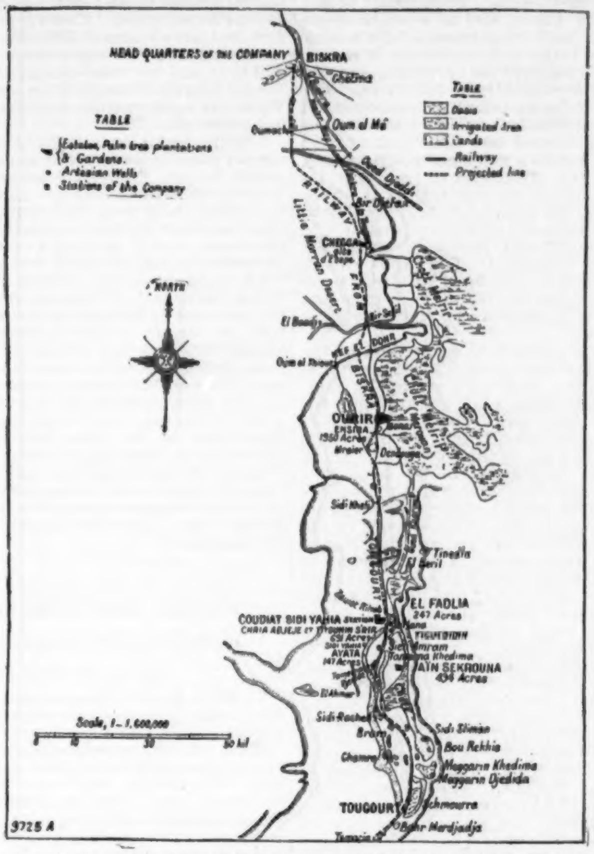
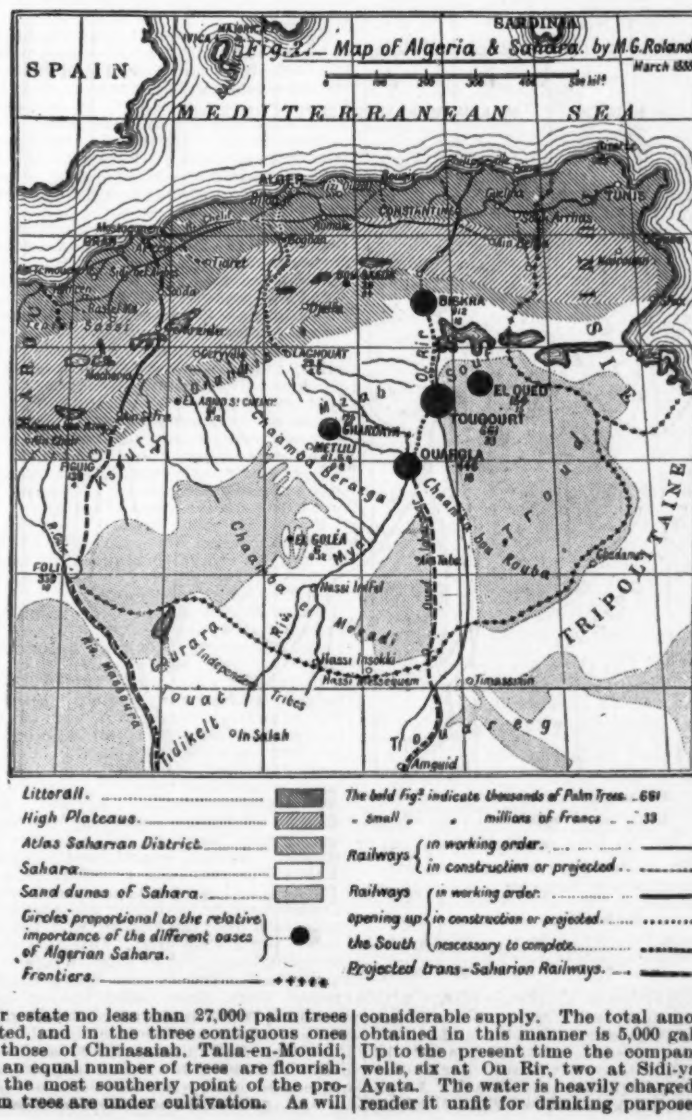



FIG. 1.—MAP OF THE OUED RIR', SHOWING THE ESTATES OF THE BATNA AND SOUTH ALGERIA COMPANY.

be readily supposed, these results have not been obtained without the expenditure of considerable sums and a great deal of patient labor. The water-bearing strata are met with at a depth of about 230 ft. below the surface. The most favorable formation is a great mass of fluid sand, the water held in which is imprisoned and kept under pressure by an impermeable mass of rock that had to be bored through. As soon as the water is reached it rises freely through the bore, sometimes forming a jet several yards in height, but after a time this settles down to a steady flow and yields a




On the Ou Rir estate no less than 27,000 palm trees have been planted, and in the three contiguous ones further south, those of Chrisaiah, Talla-en-Mouidi, and Sidi-yahia, an equal number of trees are flourishing. At Ayata, the most southerly point of the property, 7,000 palm trees are under cultivation. As will

considerable supply. The total amount of discharge obtained in this manner is 5,000 gallons per minute. Up to the present time the company has sunk nine wells, six at Ou Rir, two at Sidi-yahia, and one at Ayata. The water is heavily charged with salts which render it unfit for drinking purposes, though it does

not affect its usefulness for irrigation. In some places the pressure of water has been sufficient to break through the overlying rock and form small lakes or reservoirs, in which plenty of fish are found, and, what is extremely curious, several varieties of fish, crustacea, and mollusks are thrown up with the water that flows from the artesian wells. The ground at and near the surface is very sandy, and at a slight depth below it becomes hard and conglomerated by a large admixture of gypsum; the soil, therefore, is not of such a nature as is well adapted for agricultural operations, and requires enrichment by fertilizers. The company is indebted to the well sinking department of the Algerian administration for sinking its wells, the administration having carried out this work at fixed prices. The undertaking is a sufficiently serious one, chiefly on account of the difficulties of transport, 150 dromedaries being required for the transport of the plant. It rested with the company's engineers, however, to locate the positions of the borings, and in this, partly by good judgment and partly by good luck, they have been very successful. The wells, which have a final diameter of 8 in., are lined with iron tubes throughout, and every care is taken to insure that the rising column only flows through the opening at the bottom of the tube.

In all, 50,000 palm trees are now in cultivation by the company, and though the conditions of success, so far as sun and water supply are concerned, are never wanting, the labor of establishing and maintaining the plantations is no light one; great care has to be taken in the preparation of the ground and the formation and irrigation of drainage channels. Only about eighty palm trees can be planted to the acre. The date palm (*Phœnix dactylifera*) is the principal variety cultivated. In good seasons and under favorable conditions, the crop from each tree yields a profit of ten francs, but only about four or five francs profit can be taken as an average, representing a net revenue in round figures of about fifteen francs an acre. Although the plantations are not yet in full and vigorous bearing, the company exports large quantities of dates, the season of 1888–89 having yielded over 130 tons, all of which is exported into France.

It is not only for the fruit that the tree is cultivated, because almost all parts are useful for conversion to some purpose or another; the roots, trunks, leaves, and branches all have their value, while various pharmaceutical and other products are obtained from them. For example, a very astringent resin is produced from the cellulose of the tree, which finds application in pharmacy for healing wounds. The pollen of the male plant is made use of in preparations for the skin, and the roasted stones of the dates are employed largely in Africa as a substitute for chiccory and even coffee. Besides the palm, a considerable variety of plants are cultivated by the company; thus henna and madder appear to adapt themselves admirably to the moist, sandy soil, and require no fertilizing. The henna, which grows to a shrub of considerable proportions, produces a crop the second year after the seed has been sown; it flowers in the month of August, and, when the seed has ripened, it and the leaves are stripped from the shrubs; it is from the latter that is obtained the dye that is so largely used among Eastern nations. The madder plant becomes productive during the second year. In districts where aniline dyes have not yet found their way, this plant is in great demand for staining the wool from which clothing, carpets, and other goods are manufactured. Cotton, flax, and tobacco are also cultivated, but up to the present time only on an experimental scale. The climate appears well adapted for the culture of the cotton plant, which lasts in full bearing vigor for twenty years. The cost of transport, however, renders it impossible for this class of crop to compete successfully with more favored districts, although there is a certain local demand. Rye grass, drinn, which is a species of alfa, and lucern, flourish in certain parts of the oases, and the latter grows extremely well in the palm tree plantations, which are kept thoroughly irrigated, and all crops of this kind are sufficiently abundant to provide ample fodder for the cattle.

Under the shade of the palm trees it is found that vegetables can be grown with advantage, of course only for the use of the employes of the company. Certain classes of pepper naturally flourish, and an interesting experiment is now being made to introduce varieties of vines, with the view of producing crops of dried raisins for export. Of cereals, millet, maize, and a few others of tropical habits grow in profusion, while wheat and barley appear to accommodate themselves to the climate, provided that they are kept supplied with plenty of water.

The operations of the company may be summarized in a few words. In seven years, that is, from 1882 to 1889, they have created three oases and three villages, they have sunk nine artesian wells, securing a water supply of about 5,000 gallons a minute; they have reclaimed and put under cultivation over 900 acres of land, and have planted 50,000 palm trees; they have constructed more than twenty-five miles of irrigation canal, and built houses and cottages for the workmen, as well as stores and depots. All this has been carried out for about £30,000, and there is every prospect at the present time of the adventure turning out a profitable one. It could scarcely have been hoped that it would have been productive sooner, considering the heavy reclamation work that had to be done and the length of time required to develop the palm plantations. But in any case the undertaking is a highly interesting one, and reflects much credit on the capitalists and their engineers. These latter have solved the problem of reclaiming and fertilizing the desert, whether it turns out to be a commercial success or not.—*Engineering.*

## RAISINS.

THE United States consul at Malaga, Spain, transmits to the State Department the following report on raisins:

"The large production of California raisins within the last two years has had a disastrous effect upon the sales and shipment of Malaga fruit to the United States. The Spaniards are beginning to realize the fact that there are other countries besides Spain where raisins can be successfully produced. In 1882, the crop of raisins produced in Malaga reached 1,900,000 boxes, of which there were shipped to the United States nearly 1,000,000 boxes. Since that time the shipments to the United States have been gradually but steadily decreasing, until in 1888, when the total production only amounted to about 700,000 boxes, of which 112,000 only have been exported to the United States. This is a fearful decline in six years, but it is partly owing to the decline in the yield. There are many persons who predict that the vintage of 1889 will reduce still further the purchases made for exportation to the United States, and that in a few years Malaga raisins will be replaced for our home consumption by those raised in California. There are other reasons why the raisin trade of Malaga has fallen off.

"In the first place, raisins are not used now as in former years as a dessert at almost every hotel table or public dinner. Twenty years ago a public dinner was never given without them. Again, there is the perfection with which fresh fruit is put up. Fruits in their own juices are offered for sale in almost every part of the world, and at so small a cost as to have changed entirely the use of dried fruit. People prefer fresh fruit, and it is offered at such a reasonable price that it is within reach of almost every one. The vines of the province of Malaga for the last ten or twelve years have, in certain localities, suffered greatly from phylloxera, but here the attack of this plague has been slow, appearing to the eastward of Malaga first, in isolated places. When found they would replant by grafting the American riparia vine, but it takes four or five years before these new vines begin to yield. This has been going on for years, and where vineyards would produce from new vines others would be attacked, so that the former total crop, say in 1882, has not lately been produced. But I may add that in a few years the yield will compare favorably with former times, and prices, with California competition, will be considerably reduced."

[REPORTS FROM THE CONSULS OF THE UNITED STATES.]

## COOKERY FOR WORKINGMEN'S WIVES.*

Report by Consul UNDERWOOD, of Glasgow.

### BREAD, SCONES, AND CAKES.

*To Make Bread.*—Seven pounds flour, 2 ounces German yeast, 1 teaspoonful sugar, 1 tablespoonful salt, a little butter, and a little more than a quart of water.

Mode: Take 2 tablespoonfuls of flour, the sugar and yeast, with a cupful of tepid water (the water to be the heat of new milk), set it near the fire to rise for half an hour. Put all the flour but one handful into a basin, mix well with the salt; if the yeast has risen well, you will have light bread. Add the yeast and a quart of tepid water to the flour in basin, knead it with the hand until smooth; then take the butter and rub over the dough. Cover the basin with a cloth, set it near the fire, let it rise for three hours; then divide the dough into loaves, and bake for one and a half hours in a moderate oven. If the oven is too cold, the bread will not rise; if too hot, it will destroy the yeast.

*Wheat Meal Bread.*—Ingredients, 2 pounds wheat meal, 2 teaspoonfuls of baking soda, 2 teaspoonfuls cream of tartar, 1 teaspoonful salt, 1 teaspoonful sugar, 2 teaspoonfuls dripping, and not quite a quart of buttermilk.

Mode: Mix the wheat meal, the baking soda, cream of tartar, salt, sugar, and dripping well together; then stir in the buttermilk, and mix quickly and thoroughly for not more than ten minutes. Put into a tin and bake in rather a quick oven for one and a half hours. This will make two loaves at least.

*Soda Bread.*—Ingredients, two pounds of flour, 2 pounds Indian meal, 3 teaspoonfuls of baking soda, 3 teaspoonfuls cream of tartar, 1 large teaspoonful salt, 1 large teaspoonful sugar, a little more than a quart of buttermilk.

Mode: Mix all the dry ingredients well together, then stir in the buttermilk; mix well and divide it into three or more loaves, and bake in a tin in rather a quick oven; time, one hour. Very wholesome.

*Soda Scones.*—One-fourth stone flour, large teaspoonful baking soda, one teaspoonful cream of tartar, buttermilk, and a small teaspoonful of salt.

Mix the dry ingredients together thoroughly and lightly; add the buttermilk to make the dough, and divide into from four to six pieces. Sprinkle a little flour on the baking board, and roll out the dough with rolling pin to about a quarter of an inch thick. Cut in four and bake on a hot griddle till of a pale brown; then turn and bake the other side the same.

*Steamed Brown Bread.*—One pound Indian meal, half a cup of treacle, salt, 1 teaspoonful baking soda, and 1 teaspoonful cream of tartar.

Mode: Mix meal, treacle, a pinch of salt, baking soda, and cream of tartar well together; then add enough buttermilk to make a firm dough; mix quickly, and put into steamer or basin, and steam in fast boiling water for four hours.

*Baked Brown Bread.*—One pound wheat meal, 1 pound Indian corn meal, half a cup of treacle, salt, 1 egg, 2 teaspoonfuls of baking soda, 2 teaspoonfuls of cream of tartar, milk or water.

Mode: Mix wheat meal, Indian meal, half teaspoonful salt, baking soda, cream of tartar well together; warm the treacle and add it, with the milk (or water), to the dry ingredients; put in floured tin, and bake five hours in a moderate oven.

*Oat Cakes.*—Mode: Put 1 pound of oatmeal into a basin, a very small pinch of baking soda, and a small teacupful of tepid water; mix well. Spread some dry meal on the baking board, lay the dough on it and knead with knuckles till you have it half the size wanted. Roll out smooth, and finish with rolling pin; it should be very thin. Cut in three, and rub well with dry meal on both sides; put them on the griddle. The fire must not be too quick; when quite dry (not brown), take them from the griddle, and toast the other side before the fire till crisp. One teaspoonful of melted dripping is thought by some to be an improvement.

*Wheaten Meal Scones.*—One pound wheat meal, 1 pound flour, teaspoonful baking soda, teaspoonful cream of tartar, teaspoonful dripping, half teaspoonful salt, and a little buttermilk.

Mode: Mix the meal, flour, baking soda, cream of tartar, dripping, and salt well together; then add the buttermilk to make a light dough; divide, and roll out to the thickness of a quarter of an inch, and bake on not too hot a griddle.

*Rice Scones.*—One pound rice, one-fourth pound flour, 1 teaspoonful sugar, and half teaspoonful salt.

Put the rice, sugar, and salt into a saucepan, with 1 quart water, and let it come to the boil. Then set it to the side of the fire, and let it steam for two hours with the lid close till all the water has been absorbed and the rice has become soft; then sprinkle the flour on the baking board and turn the rice out on it. Let it stand till cool; then divide into six parts, and roll out very thin. Cut each part in three, and bake on not too hot a griddle.

*Potato Scones.*—Potatoes, flour, and salt.

Take any boiled potatoes left from the dinner; bruise them nice and smooth on the table or baking board; add salt to season; then shake some flour over them or work it in, roll out very thin, prick with a fork, and cut in three. Bake on not too hot a griddle.

*Scalded Scones.*—One pound flour, one-half teaspoonful salt.

Mix the flour and salt together, and add boiling water enough to make a good, firm dough, then divide it, and roll out very thin on the baking board sprinkled with flour. Cut in three, and bake on not too hot a griddle.

*Indian Meal and Flour Scones.*—One pound Indian meal, 1 pound flour, 1 tablespoonful treacle, 1 teaspoonful baking soda, 1 teaspoonful cream of tartar, half a teaspoonful salt, and buttermilk.

Mix all together, and then add enough buttermilk to make a nice, soft dough; divide it, and roll out each piece into about a fourth of an inch thick. Cut in four, and bake on not too hot a griddle.

*Barley Meal Scones.*—Two pounds barley meal, three-fourths teaspoonful baking soda, three-fourths teaspoonful cream of tartar, half a teaspoonful salt, and buttermilk.

Mix, and add enough buttermilk to make a nice, soft dough; then sprinkle a little meal on the baking board, and roll out to a fourth of an inch thick. Cut in three, and bake on not too hot a griddle.

*Crullers.*—One and one-half pounds flour, one-half pound sugar, one-fourth pound butter, 2 eggs, 2 teaspoonfuls baking powder, milk and lemon.

Mode: Butter and sugar, beat to a cream, add flour and milk alternately till all are in; beat up the eggs very lightly; grate the rind of the lemon into the flour, and add the juice; then put in baking powder, mix well, roll out to a quarter of an inch thick, divide into small rounds, cutting center out of each to form rings. Fry in hot fat a light brown. The quantities given will make eighty-five crullers.

*Cocoanut Cake.*—One-half pound sugar, 1 pound flour, one-fourth pound butter, milk, 1 cocoanut, 2 eggs, and 1 large teaspoonful baking powder.

Mode: Grate cocoanut. Beat butter and sugar to a cream, beat the eggs very light, and by degrees add the milk and flour; then cocoanut and baking powder, and a pinch of salt. Bake in a tin or mould for two hours.

*Small Cocoanut Cakes (good for children).*—One cocoanut, 1 egg, half a gill milk, one-fourth pound sugar, one-fourth pound flour, half a teaspoonful of baking powder, and 1 tablespoonful corn flour.

Mode: Mix corn flour, sugar, baking powder, and flour well together; add milk and cocoanut grated, beat up the egg well, and add. Divide the mixture, and work it with your hands into small cones or drops. Bake on buttered paper in a quick oven.

*Ginger Bread.*—One pound flour, one-half pound treacle, one-half pound sugar, one-half pound lard, 3 eggs, a large teaspoonful of ginger, a teaspoonful of cinnamon, half teaspoonful cloves, 2 teaspoonfuls of baking powder, half a nutmeg grated, a little salt, and milk.

Mode: Melt the lard, sugar, and treacle in a saucepan. Beat up the eggs well, mix the flour, baking powder, spice, and pinch of salt well together; add the melted lard, sugar, treacle, and eggs. Use a little milk to make a soft batter, and bake in a moderate oven one and a half hours. Fruit can be added to this cake—raisins, currants, or almond—which will make it richer.

*Rough Robin.*—One and one-half pounds of flour, one-half pound rice flour, one-half pound lard or butter, one-half pound sugar, 1 pound currants, 1 pound sultana raisins, 2 teaspoonfuls baking powder, 1 teaspoonful ground caraway, 1 teaspoonful cinnamon, and a little salt.

Mode: Mix lard, flour, sugar, baking powder, spices, and a pinch of salt well together, and beat well. Then add fruit. Mix with buttermilk to make a stiff batter. Bake for two hours.

*Rice Cake.*—One pound flour, one-half pound rice, one-half pound sugar, one-half pound butter. 4 eggs, 2 teaspoonfuls of baking powder, 1 teaspoonful essence of vanilla, salt and milk.

Mode: Beat butter to a cream, add the yolks of the eggs and the sugar; beat very lightly. Then add the flour (after being well dried before the fire or in the oven), baking powder, pinch of salt, vanilla, and sufficient milk to make a nice, thick batter. Beat up the whites of the eggs to a stiff froth, and add them last. Mix all very lightly, and bake for two hours in a moderate oven.

*Seed Cake.*—One pound flour, one-half pound sugar, one-half pound butter, 3 eggs, 2 spoonfuls caraways, milk and a teaspoonful baking powder.

Mode: Mix butter to a cream, add yolks of eggs, sugar and flour (well dried), baking powder, seeds, pinch of salt, and milk to make a stiff batter. Beat white of eggs to a stiff froth, and add them last. Stir very lightly, and bake one and a half hours.

*Sultana Cake.*—One pound flour, one-half pound sugar, one-half pound lard, 3 eggs, 1 pound sultana raisins, the rind of a lemon grated, 1 large teaspoonful baking powder, salt and milk.

Mode: Mix the lard, flour, yolks of eggs, baking powder, pinch of salt, sugar, and raisins well together; and add enough milk to make a stiff batter. Beat the whites of eggs to a stiff froth and add, mixing very lightly, and bake for one and a half hours.

*French Cake.*—One pound flour, three-fourths pound sugar, one-fourth pound butter, 2 eggs, milk, large teaspoonful baking powder, and salt.

Mode: Beat butter and eggs to a cream; add the sugar and flour by degrees, and mix with a little milk to a stiff batter or soft dough. Add the salt and bak-

* Continued from SUPPLEMENT, No. 733, page 11718.

ing powder last; mix all well, and bake in a moderate oven one and a half hours.

*Pancakes.*—One pound flour, fourth pound sugar, 1 egg, a teaspoonful carbonate of soda, a teaspoonful cream of tartar, buttermilk.

Mode: Beat sugar and egg very lightly, mix in by degrees the flour and milk, work well, add soda and cream of tartar last. Take a little dripping in a piece of clean muslin, rub over the griddle; drop batter in spoonfuls. When one side is done, turn them.

*Pancakes.*—Rub 1 pound flour, 2 ounces dripping, teaspoonful carbonate of soda, teaspoonful cream of tartar, one-fourth pound sugar, all well together. Add buttermilk to make a soft batter. Rub the griddle over with dripping, and put a spoonful on for each pancake. When one side is done, turn. Can be flavored with anything that is liked, or currants may be added.

SICK ROOM COOKERY.

*Mustard Poultices.*—Dry mustard, cold water.

Mix enough cold water with the mustard to make it into a thick paste; when quite smooth, spread it upon a piece of thin old linen, or cotton; sew it round so as to form a bag. Be careful not to make the poultice larger than required; hold it to the fire for a few minutes, so as not to chill your patient; time, from fifteen to thirty minutes; have ready a piece of clean soft cotton, or a piece of clean wadding, and when you take off the mustard poultice, put on the wadding or the cotton.

*Bread-and-Milk Poultice.*—Stale bread, cold milk.

Boil bread with enough milk to make a thick pulp; spread it on a piece of soft cotton and apply it very hot. This poultice is often applied without a cloth between it and the affected part, but poultices put into a bag are cleaner and easier rewarmed. Bread poultices are cleansing and soothing.

*Linseed Meal Poultices.*—Linseed meal, boiling water.

Put sufficient meal to make the poultice the size required into a hot bowl, and pour on boiling water enough to make a soft paste; beat quickly for three minutes, or till it looks oily. Have ready a flannel or cotton bag, the size required; pour in the paste, sew up the mouth of the bag quickly. Apply the poultice to the affected part as hot as can be borne.

If ordered with mustard, mix a tablespoonful of dry mustard with the meal. Good for inflammation.

*Fomentation of Camomile Flowers.*—Two ounces camomile flowers.

Put into a jar with 2 teacupfuls of water, cover jar very close, let it come to the boil, and infuse for fifteen minutes, keeping lid close on jar all the time; strain off the hot liquor, keep it hot, dip pieces of flannel into it, and apply externally to the part affected. Good to allay swelling and inflammation.

*Bran Poultice.*—Make it like porridge, and put it into a bag. Be sure not to make it so soft as that any water will trickle down to annoy the patient.

*Linseed or Flaxseed Jelly for a Cough.*—One pound linseed, 1 large lemon, one-fourth pound raisins, one-half pound sugar.

Boil the linseed in 2 quarts of water, then let it simmer for three hours; strain; return to the pot with raisins and pulp of lemon, and simmer, without boiling, one hour; strain again, add the sugar. Take a teaspoonful (two or three times a day). This is very good.

*Gruel.*—Two tablespoonfuls of oatmeal, 2 cups of cold water, half teaspoonful sugar, pinch of salt.

Put the oatmeal into a bowl with the cold water, let it stand for fifteen minutes; then with a spoon press all the flour from the oatmeal, and pour into the pan, leaving the meal as dry as possible; put the pan on the fire, and stir it till it boils; then simmer for ten minutes, add the sugar, and serve hot.

Some prefer gruel without sugar, and some with milk instead of water, or a little butter and a scrape of nutmeg.

*Barley Water.*—Two tablespoonfuls of barley, 2 quarts of water, 1 tablespoonful of sugar.

Wash the barley well; put the barley and water into a saucepan and bring it to the boil; then boil very slowly for two hours, strain it, add sugar, and let it cool. Barley water is very cooling and nourishing. The barley may afterward be used for a pudding, or put into soup.

*Beef Tea.*—One-half pound of gravy beef, 2 gills water.

Cut the beef very small; put it into a jar, sprinkle a very little salt over it to draw out the juice of the meat quickly, add the water, cover the jar with paper twisted close over it; let it stand for half an hour; place the jar in a pan of boiling water; keep it boiling for half an hour, and you will have good, nutritious beef tea, easily digested by an invalid.

*Veal Tea.*—One pound veal, 1 large cup of water.

Cut the veal up very small, sprinkle a very little salt over it; put it into a jar, add the water, cover closely with paper; let it stand for half an hour; place the jar in a saucepan of boiling water, and let it boil for two hours.

*Suet or Milk Porridge for Invalids.*—One tablespoonful suet, 2 tablespoonfuls flour, 1 teacup of milk, a little salt.

Mince the suet very fine; mix milk and flour till smooth, then put into a pan; add suet and a pinch of salt; boil very gently for ten minutes, and serve hot. This is very good and nourishing, especially for those who cannot take cod liver oil.

*Fish for an Invalid.*—One small fish, a small sprig of parsley, 1 tablespoonful of milk.

Get a nice, fresh whitefish; clean it well; put it into a small jelly jar with the milk and parsley well washed, cover very closely with paper, and set it in a saucepan of boiling water at the side of the fire for half an hour. This is a very light way of cooking fish for an invalid. It can be skinned and boned if preferred.

*Egg with Tea, Coffee, Cocoa, or Milk.*—Break the egg into a teacup, beat with a fork till well mixed; pour in the tea, coffee, cocoa, or milk gradually, stirring all the time. This is very nourishing, and good in cases of exhaustion from overwork or strain.

*Lemonade.*—One lemon, a large cup of boiling water.

Roll the lemon on the table to soften it; pare the rind very thin (for the white part is very bitter), squeeze the juice into a jug, taking care not to let any pips in, as they are too bitter, add the lemon rind and the boiling water, cover the jug; let it stand till cold, strain and use. Very cooling.

For a pleasant drink add a teaspoonful of sugar; but not in cases of sickness.

*Breadberry, or Toast Water.*—One slice bread, a large cup boiling water.

Toast the bread on both sides till quite dry and a nice brown, but not burnt; break it, and put it in a jug, pour the boiling water over it, and cover; let it stand till cold, and strain. Cooling.

*Koumiss, or Milk Wine.*—One quart buttermilk, 2 quarts sweet milk, 4 teaspoonfuls sugar.

Mix the buttermilk and sweet milk together, add the sugar, and stir till melted. Let stand near the kitchen fire for twelve hours covered with a cloth, then bottle. As it is an effervescing drink, the cork must be tied down and the bottles kept on their sides. When the koumiss is opened, it should be used.

*Useful Homely Receipt for a Cold or Cough.*—One ounce Spanish juice, 2 ounces honey, one-half pound treacle, 1d. worth laudanum, 1d. worth oil of peppermint, 1 pint water.

Boil down 1 pint of water with the Spanish juice, honey, and treacle in it to a gill; let it get cold, and add laudanum and oil of peppermint. Bottle tight, and shake the bottle before using. Dose for an adult, a tablespoonful night and morning.

*Croup.*—A very good and simple remedy for croup is a teaspoonful of powdered alum and 2 teaspoonfuls of sugar; mix with a little water, and give it as quickly as possible, a little at a time, and instant relief will be given.

ROASTING.

To ascertain the length of time required for roasting, weigh the meat and allow a quarter of an hour to every pound and one-quarter of an hour over. If, however, the piece of meat is very thick, allow half an hour over. Young and white meat (veal, lamb, and pork) requires twenty minutes to each pound and twenty minutes over. They are unwholesome when underdone.

Before beginning to roast sweep up the hearth and make up a large fire in a well polished fireplace an hour before it is wanted, so as to have it bright and glowing. Do not let the fire go down while the meat is roasting; add small pieces of coal or large cinders occasionally so as to keep it up. Hang the meat, by the small end, to the hook of the jack. When there is no jack the meat may be hooked to a skein of twisted worsted, suspended from a hook projected from the mantel shelf. Wind up the jack, or twist the worsted, so as to make it spin slowly. Place the dripping pan under the joint.

If you have a meat screen, see that it is bright (so as to throw back the heat upon the joint), and place it before the fire. Meat should be placed for the first ten minutes as near the fire as possible, without scorching; the great heat hardens the outside, and keeps in the juices. Baste it as soon as the fat melts. Basting prevents the meat from becoming dry and scorched. Then withdraw the meat 18 or 20 inches from the fire, and baste it very frequently while roasting with the dripping produced by the melting of the fat. If the meat is lean, it must be basted with dripping melted for the purpose. The meat may be dredged with flour a quarter of an hour before it is quite ready, to make it browner and to thicken the gravy a little. When it is ready and placed on the ashes, sprinkle it with a little salt. Before making sauce of the brown gravy pour away the dripping from the dripping pan (keep this dripping for other purposes); add a little boiling water to the brown gravy left in the pan; mix well; add a little salt, and pour it round the roast, not over, or it will sodden the meat.

*To Roast Meat in the Oven.*—Place the meat in a baking tin, in a very hot part of the oven, for five minutes, to harden the outside and keep in the juice. Baste it as soon as the fat melts; then remove it to a cooler part. Place beside it a cup or basin of water, to keep the air of the oven moist without cooling it. Baste the meat frequently. For the length of time required, see preceding directions.

All ovens in which the meat is cooked should be properly ventilated, in order to allow the escape of an injurious vapor produced by meat when cooked in a close oven. Meat roasted in the oven is not considered so digestible as when roasted before the fire.

*Roasting in the Pot or Saucepan.*—This way of roasting is especially suitable for small pieces of meat, and is far more economical, because of the small quantity of fuel required. Melt and heat a tablespoonful of dripping in a pot. Brown all sides of the meat in this, so as to harden the outside and keep in the juice. Then draw the pot to the side of the fire and let the meat cook slowly with the lid on, basting it frequently. Time required, same as in previous directions.

FRYING.

*To Fry a Steak.*—Having got your steak, which must not be thinner than half an inch, and not thicker than an inch, take the suet, which is always given with the steak, chop it fine; see that your pan is perfectly clean and dry. Place the pan on the fire with the suet; let it remain until the suet is melted and rather hot. Take hold of the steak at one end with a fork, dip it in the pan, and keep it for two minutes; then turn the other side for two or three minutes, according to the heat of the fire; then turn it. It will take about twelve minutes to cook, and requires to be turned on each side three times during the cooking. Take care that the pan is not too hot, or it will burn the gravy, and perhaps the meat, and lose all the nutriment; you must not leave the pan, but carefully watch it all the time. If not turned very often it will be noticed that the gravy will come out on the upper surface of the meat, which in turning over will go into the pan and be lost, instead of remaining in the meat. Always, in lifting, insert the fork in the fat. Serve on hot plates with salt, pepper, and the gravy round it.

*To Fry a Mutton Chop.*—Get some nice loin chops, cut the same thickness all through. Have your frying pan very clean; put in a little dripping or lard; let it get rather hot. As soon as it begins to smoke take the chop with a fork by the small end and dip it in the fat for a minute; then turn it and let it fry for three minutes; you can turn it several times, it will take ten minutes to cook a chop an inch thick with a good clear fire. Add salt and pepper; have a nice hot plate, and lift carefully, always putting the fork in fat. Pour the gravy round it.

*To Broil a Rump Steak.*—Get your steak three-quarters of an inch thick (if it should be cut rather thicker in one part than another, beat it well with a chopper). Before cooking a steak stir up the fire (say half an hour before you intend to use it); clear away the ashes, stir all the dead cinders from the bottom, and in a few minutes you will have a clear fire fit for the use of the gridiron. Place your gridiron, with the steak, about 5 inches above the fire, and keep constantly turning the steak, to keep the gravy in. Put the fork, not into the lean part, but into fat to turn it. One pound of steak three-quarters of an inch thick will take about twelve or fifteen minutes to cook with a nice clear fire. Serve hot on a hot plate.

(*To be continued.*)

## THE WEIGHT OF WATER.

SCIENCE is correcting itself in the department of weights and measures. It is now discovered that a gallon of water, according to the capacity hitherto prescribed for it, does not weigh 70,000 grains, and consequently it is incorrect to say that "a pint of water weighs a pound and a quarter," unless we allow an increased volume for the pint. The correction to be made is not much; but still it is something.

In June, 1824, an act of Parliament was passed, coming into operation on January 1st, 1826, which was thought to settle this matter once for all.

In that statute it was declared that if the imperial pound, as represented by a brass weight in the custody of the clerk of the House of Commons, happened to be lost, defaced, or otherwise injured, it should be restored by comparison with a cubic inch of distilled water, weighed in air by brass weights, at the temperature of 62° Fah., the barometer being at 30 in. Such cubic inch of water was stated to be equal to 252·458 grains, the standard troy pound being 5,760 such grains, and the avoirdupois pound 7,000 such grains troy.

The gallon was specified as the standard measure for capacity, and was to be equal in bulk to 10 lb. avoirdupois of distilled water, weighed in air in the manner already described.

The capacity of the imperial gallon thus became 277·274 cubic inches, representing 70,000 grains. In like manner a cubic foot of water was reckoned to weigh 62·321 lb. avoirdupois. The same standard in respect to the cubic inch, and consequently the cubic foot, was adopted in the Sale of Gas Act of 1859. But a report from the standards office of the Board of Trade has just been issued, by which it appears that experiments have been in progress in the department since the year 1878, with a view to ascertain "what is the true weight of a cubic inch of distilled water."

It is shown that the law passed in 1824, regulating the weights and measures, was in reality based on weighings made as far back as 1798. In 1870 there were distinct differences among scientific authorities as to the true weight of a given volume of water, and it was for this reason that it was deemed unadvisable to re-enact, in the Weights and Measures Act of 1878, so much of the act of 1824 as fixed the weight of the cubic inch at 252·458 grains.

The experiments at the standards office have now at last landed us in the conclusion that water is not quite so heavy as the act of 1824 declared it to be, the cubic inch being only equal to 252·286 grains.

The excess is only about one-sixth of a grain in a cubic inch, but a "note" attached to the report rightly specifies the old estimate as "erroneous for scientific purposes," and it is suggested that in any future legislation on this subject it may be desirable to consider whether the new value for the cubic inch might be substituted for the old and incorrect.

It is of some interest to observe how far the new value affects the old reckoning. Water is a shade lighter than we thought it to be, so that we lose nearly 48 grains in the gallon, the 70,000 grains giving place to 69,952. Or else we must give the gallon greater capacity.

In a cubic foot of water we lose 297 grains, or nearly three-quarters of an ounce. The pint, considered as the eighth part of 277·274 cubic inches, drops from 8,750 grains to 8,744, creating a loss of six grains, or more correctly, 5·96.

The excess has not been much, and yet it is to be regretted that the matter was not set right at first. It seems curious that a problem so close to our hands should have remained so long unsettled.

When the measurement relates to the distance of the earth from the sun, we expect to find that the earlier calculations are susceptible of correction. But most of us thought that we had a firm foundation in the table of weights and measures.

It proves that the weight of a cubic inch of water was overestimated. Consequently the number of cubic inches corresponding to 10 lb. of water was underestimated, and the gallon was made proportionately too small, together with all the derived measures. Still, to do our scientists credit, we must remember that the error in this case is less than one part in 1,400. When Sir J. Herschel was defending the character of astronomical science, in view of an error of nearly 4,000,000 of miles in estimating the sun's distance, the correction was shown to apply to an error of observation so small as to be equivalent to the apparent breadth of a human hair at a distance of 125 feet, or a sovereign eight miles off.

Moreover, the error had been detected by the astronomers themselves, and the needful correction applied. It happens that another correction has been made since that date, as recently as a year ago, showing that the error in regard to the sun's distance was not so great as the distinguished astronomer supposed.

So by degrees we get to the truth, and may be supposed now to know the real weight of distilled water. The correct observation of common things is not so easy as many people suppose, and difficulties unknown to the multitude beset the path of absolute accuracy. It needed the mechanical genius of Sir Joseph Whitworth to produce so seemingly simple a thing as a perfect plane, which everybody thought was actually accomplished before.

The table of our weights and measures has now to be amended to this extent, that a gallon of water weighing 10 lb. requires a capacity of 277·463 cubic inches, instead of 277·274, the enlargement being rather less than one-fifth of a cubic inch. The capacity of the pint becomes 34·683 in., instead of 34·659. The difference in the cubic foot we have already noticed.—*The Engineer.*

## DETECTING SILVER IN LEAD.

By ALEXANDER JOHNSTONE, F.G.S. (London and Paris).

As silver and lead very commonly occur in nature combined together in the same mineral substances, a more easy, rapid, and correct method for the detection of the former in the presence of the latter than any of those generally adopted in practice has for a long time been greatly desired, especially by assayers and mineralogists.

The author, who has spent much of his time in the determination of naturally occurring argentiferous lead compounds, has attempted to supply such a method in the extremely simple one detailed below, and he hopes it may prove, in the hands of others, as successful as it has invariably been with himself.

When a mineral which contains both of the above metals is heated, in the ordinary course of blowpipe analysis, on charcoal with fusion mixture

$$(K_2CO_3+Na_2CO_3),$$

in the inner or reducing flame, it yields, as is well known, a malleable metallic lead (usually lead gray in color), which is an alloy of silver and lead. The silver is readily detected in this alloy* by treating it as follows: Place it in an evaporating dish and cover it well over with moderately strong nitric acid, and then boil the liquid till the bead or beads dissolve; next nearly neutralize the solution thus obtained with sodium carbonate, in a rough manner, but so that it will remain weakly acid after the operation.

In this prepared solution now allow to lie for some time two strips—one of bright copper and the other of zinc. The lead of the solution soon becomes deposited on the zinc, while the silver almost entirely goes to coat the copper foil; lift out the latter, and apply to the deposit on it a drop of fairly strong nitric acid, and then quickly afterward a drop of potassium chromate solution. Or, dip the coated foil into moderately strong nitric acid for an instant, and then into a dish containg potassium chromate solution.

The reddish brown mass which forms at once either on the upper or under side of the foil is a sure indication of silver. The deposit on the zinc may be treated in the same way, and the lemon yellow mass of lead chromate which results will contrast well with the brown incrustation obtained on the copper. If no silver is present in the solution, the copper foil will scarcely become coated at all when placed in it.—*Chem. News.*

## OIL OF MAIZE OR CORN.†

By CHARLES EDWARD BOWERS, Ph.G.

To extract the oil from the seed, corn was taken in the different stages of its growth to ascertain at what age it contains the largest amount of oil. The corn was carefully dried, after which it was removed from the cob, reduced to a coarse powder, and percolated with petroleum ether to remove the oil. The youngest specimen tried contained 1 per cent. of its weight of oil. The amount gradually increased with the age of the corn until the maximum was reached in that which was allowed to fully ripen and dry upon the stalks. The amount yielded by such corn was 3·16 per cent.

The oil is said to reside entirely in the embryo or germ of the corn, and to ascertain if such be the case a portion of the corn was carefully deprived of its embryo, coarsely powdered and percolated with petroleum ether; no oil was obtained. The germs, on the other hand, freed from all integuments and treated in the same manner, yielded 22 per cent.

As obtained, the oil was of a pale yellow color and had a somewhat thicker consistence than either cotton seed or olive oils. The odor was slight, but peculiar; its taste not unpleasant, bland and oleaginous; its specific gravity 0·917. It is a fixed oil, belonging to the group of non-drying, and is well adapted for lubricating purposes. It is soluble in all proportions in ether, bisulphide of carbon, chloroform, and benzin; very sparingly soluble in 95 per cent. alcohol, forming a milky mixture when shaken with that body, which separates on standing into two layers, both of which are perfectly transparent. The oil readily saponifies with so weak an alkali as lime water, and with potassa or soda it forms a white soap. A thin layer of the oil exposed to the air for several weeks did not show any rancidity and to all appearances remained unchanged. In this respect it compares favorably with the oils of rape seed, olive, etc.

Upon strongly heating, the oil emits characteristic smoky, irritating, and very disagreeable vapors, somewhat similar to those produced in the heating of cotton seed oil. It, therefore, would not be tolerated as an adulterant to lard, because the odor developed upon heating would certainly betray its presence. Lard itself is decomposed at high temperatures, but the odor produced is entirely distinct from that produced when oil of maize is associated with it.

It could not be used to adulterate olive oil, as it gives different results with all the tests for the identity of that body. With concentrated sulphuric acid it instantly darkens. Immersed in a freezing mixture of ice and salt, it did not deposit a granular substance, and remained nearly transparent, but became very notably thicker in consistence, so much so that it was scarcely mobile. The probability is that it consists largely of olein.

It is more easily absorbed by the skin than cotton seed or olive oils, and is an excellent vehicle for external applications. It also dissolves camphor with more facility than those oils.

Numerous preparations of the Pharmacopœia were made by substituting oil of maize where cotton seed oil is directed, to ascertain whether it is capable of replacing that body. The results were very satisfactory in every case. In some instances its superiority over cotton seed oil was very well marked. In the preparation of ammonia liniment this feature was most prominent. The oil readily saponified on the addition of the ammonia water, forming a smooth, creamy mixture, which did not become curd-like or separate on standing, as is frequently the case with the officinal liniment of ammonia. Examined at the expiration of two months, no changes could be observed, and it was apparently as perfect as when first made.

The oil could be adapted to table use as a dressing for salads, etc., and could readily take the place of those oils now used for such purposes. Taken internally in the dose of a fluid ounce, it gives no medicinal effects other than those possessed by olive oil.

It is said that this oil is already an article of commerce in some of the Western States. It is a by-product in the manufacture of starch. Where corn is used as the source of that substance, it becomes an object to get rid of the oil-bearing germs, and this is done by the aid of machinery, which separates the starchy portion of the corn in one direction and the germs in another. The germs are then freed from adhering integuments as far as practicable and subjected to the action of steam, after which the oil is removed by the aid of hydraulic pressure.

* Silver, it will be remembered, is, in almost every case, present only as a *minute* constituent in lead ores.

† From the *American Journal of Pharmacy.*

CONTAMINATION OF WELL WATER.—A writer in the *Annals of Hygiene* relates a curious fact which may tend to shake the confidence of many country residents in the purity of their water supply. It is generally supposed that there is no danger of contamination if the cesspool is at a lower level than the well and at some distance from it. But in the case to which the writer refers there were two wells on the place, separated a distance of two hundred and seventy-three feet from each other, and one being fourteen feet lower than the other. Yet when water was pumped from the upper well the water in the other was very decidedly lowered, showing that there was quite free communication between the two. If the lower one had been a cesspool, the water in the upper well would doubtless have been contaminated.

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